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WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 9

IRRIGATION NEAR GREELEY, COLORADO.—BOYD

WASHINGTON
GOVERNMENT PRINTING OFFICE
1897

IRRIGATION REPORTS.

The following list contains the titles and brief descriptions of the principal reports relating to water supply and irrigation prepared by the United States Geological Survey since 1890:

1890.

First Annual Report of the United States Irrigation Survey, 1890, octavo, 128 pp.

Printed as Part II, Irrigation, of the Tenth Annual Report of the United States Geological Survey, 1888-89. Contains a statement of the origin of the Irrigation Survey, a preliminary report on the organization and prosecution of the survey of the arid lands for purposes of irrigation, and report of work done during 1890.

1891.

Second Annual Report of the United States Irrigation Survey, 1891, octavo, 395 pp.

Published as Part II, Irrigation, of the Eleventh Annual Report of the United States Geological Survey, 1889-90. Contains a description of the hydrography of the arid region and of the engineering operations carried on by the Irrigation Survey during 1890; also the statement of the Director of the Survey to the House Committee on Irrigation, and other papers, including a bibliography of irrigation literature. Illustrated by 29 plates and 4 figures.

Third Annual Report of the United States Irrigation Survey, 1891, octavo, 576 pp.

Printed as Part II of the Twelfth Annual Report of the United States Geological Survey, 1890-91. Contains a report upon the location and survey of reservoir sites during the fiscal year ending June 30, 1891, by A. H. Thompson; "Hydrography of the arid regions," by F. H. Newell; "Irrigation in India," by Herbert M. Wilson. Illustrated by 93 plates and 190 figures.

Bulletins of the Eleventh Census of the United States upon irrigation, prepared by F. H. Newell, quarto.

No. 35, Irrigation in Arizona; No. 60, Irrigation in New Mexico; No. 85, Irrigation in Utah; No. 107, Irrigation in Wyoming; No. 153, Irrigation in Montana; No. 157, Irrigation in Idaho; No. 163, Irrigation in Nevada; No. 178, Irrigation in Oregon; No. 193, Artesian wells for irrigation; No. 198, Irrigation in Washington.

1892.

Irrigation of western United States, by F. H. Newell; extra census bulletin No. 23, September 9, 1892, quarto, 22 pp.

Contains tabulations showing the total number, average size, etc., of irrigated holdings, the total area and average size of irrigated farms in the subhumid regions, the percentage of number of farms irrigated, character of crops, value of irrigated lands, the average cost of irrigation, the investment and profits, together with a résumé of the water supply and a description of irrigation by artesian wells. Illustrated by colored maps showing the location and relative extent of the irrigated areas.

1893.

Thirteenth Annual Report of the United States Geological Survey, 1891-92, Part III, Irrigation, 1893, octavo, 486 pp.

Consists of three papers: "Water supply for irrigation," by F. H. Newell; "American engineering and engineering results of the Irrigation Survey," by Herbert M. Wilson; "Construction of topographic maps and selection and survey of reservoir sites," by A. H. Thompson. Illustrated by 77 plates and 119 figures.

A geological reconnoissance in central Washington, by Israel Cook Russell, 1893, octavo, 108 pp., 15 plates. Bulletin No. 108 of the United States Geological Survey; price, 15 cents.

Contains a description of the examination of the geologic structure in and adjacent to the drainage basin of Yakima River and the great plains of the Columbia to the east of this area, with special reference to the occurrence of artesian waters.

1894.

Report on agriculture by irrigation in the western part of the United States at the Eleventh Census, 1890, by F. H. Newell, 1894, quarto, 283 pp.

Consists of a general description of the condition of irrigation in the United States, the area irrigated, cost of works, their value and profits; also describes the water supply, the value of water, of artesian wells, reservoirs, and other details; then takes up each State and Territory in order, giving a general description of the condition of agriculture by irrigation, and discusses the physical condition and local peculiarities in each county.

Fourteenth Annual Report of the United States Geological Survey, 1892-93, in two parts, Part II, Accompanying papers, 1894, octavo, 597 pp.

Contains papers on "Potable waters of the eastern United States," by W J McGee; "Natural mineral waters of the United States," by A. C. Peale; "Results of stream measurements," by F. H. Newell. Illustrated by maps and diagrams.

(Continued on third page of cover.)

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 9

WASHINGTON
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1897

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UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

IRRIGATION NEAR GREELEY, COLORADO

BY

DAVID BOYD

WASHINGTON
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1897

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, April 13, 1897.

SIR: I have the honor to transmit herewith a manuscript entitled, "Irrigation near Greeley, Colorado," and to recommend that it be published in the series of water-supply and irrigation papers. The statements therein contained have been compiled from a report prepared by Hon. David Boyd, of Greeley, Colorado, one of the early members of Union Colony, which was led by Nathan C. Meeker and given encouragement and prominence by Horace Greeley. In a short paper of this kind it is impossible to go into the details of the struggles of this colony for existence and of the development of agriculture and of a system of water control whose leading features have been widely copied. The attempt has been made, however, to present the more prominent facts and those of most interest and value to the citizens of the West who are now following in similar paths and seeking to lay the foundations for broad and lasting systems of water utilization and control by which the rights of all may be determined and protected.

The paper by Mr. Boyd is prefaced by an introduction, compiled from the records of this division and from other sources, to illustrate the climatic and topographic conditions of Cache la Poudre Valley, in which Greeley is situated, and also the limitations of water supply, since it is upon the latter that the question of growth and development must rest. The evolution of systems for obtaining and applying water to the agricultural lands and of the complicated laws and regulations are in striking contrast to the quiet, almost imperceptible development of irrigation in southern New Mexico, to be described in the next paper of this series. A comparison of the two illustrates the great differences existing between various portions of our Western country and the impossibility of transferring local practices from one point to another irrespective of natural conditions.

Very respectfully,

F. H. NEWELL,
Hydrographer in Cha ge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

VIEW OF SKY LINE CANAL.

Taking water from the upper sources of the Big Laramie River and diverting it into the Poudre above Chambers Lake at the height or 8,000 feet.

IRRIGATION NEAR GREELEY, COLORADO.

By David Boyd.

INTRODUCTION.

By F. H. Newell.

In the following paper by Mr. Boyd, a description is given of the growth and development of irrigation in the valley of Cache la Poudre Creek, in the northern part of Colorado. In this valley the best known town is Greeley, and hence this paper has been entitled "Irrigation near Greeley," as being most expressive of the location and character of the irrigation system and methods described.

Omitting the great Pacific Coast State of California, which lies for the most part outside of the strictly arid region, it may be safely claimed that Colorado stands preeminent in the extent and high degree of development of agriculture by irrigation. Here what may be termed American methods and devices for diverting and applying water to the fields have grown up, and the success attained has stimulated attempts elsewhere throughout the Western third of the United States. The same relation that Colorado holds to the rest of the arid region is borne by the Cache la Poudre Valley to the State of Colorado. It has for many years led in the construction and extension of irrigation systems, and its history may be said to epitomize the record of struggles and successes throughout the State.

The development of irrigation is not merely the result of a succession of victories over physical or material obstacles. In our country these form but a part—and, unfortunately, often a relatively small part—of the difficulties encountered by the irrigator. By far the most vexatious and expensive impediments to be removed have been those arising from the inapplicability of our laws and customs to the conditions prevailing within the arid region. Every instinct acquired through generations of life in a humid country seems to rebel against the methods of the irrigator, and every tradition of law is in direct opposition to the proper employment of the natural waters. These instincts and traditions have had to be laboriously demolished, usually after severe struggle, and the series of contests appears a never-ending one. There is little doubt that if it were possible to sum up

in one column the total expense incurred in the irrigation and reclamation of the West, and in another column the costs due to defective legislation, and especially to controversies over conflicting water rights, the latter would prove to be far the larger.

As in the development of her water resources Colorado has led the greater part of the West, so in the attempts to effect a suitable judicial and executive system having to do with water has this State been the pioneer. It can not be said that Colorado has been the most successful, for newer States, notably Wyoming, profiting by her experience, have achieved what seem to be more perfect systems; but their happiness in this regard is due largely to exertions of citizens of Colorado.

In the same way that Colorado has led in improvements in legislation have the citizens of Greeley and vicinity been the leaders in Colorado. First to experience the necessities, they have been at the front in urging needed reforms, and in these they have been notably successful. Thus it is appropriate in a series of papers devoted mainly to irrigation to review at some length the conditions near Greeley, for from here have come many initiatives to a proper state of affairs.

Considerable space is devoted in this paper to matter which at first sight may seem to be more peculiar to the lawyer than to the farmer, but, as above stated, the irrigator is called upon probably more than any other agriculturist to consider his legal environment. Although a beginning has been made, yet many years must elapse before the laws relating to irrigation, both State and national, fully recognize the necessities of the irrigator or permit such a development that the greatest good shall come to the greatest number. In a government by the people and for the people it is essential that every man become to a certain extent familiar with such defects before they can be remedied, as well as with the physical possibilities and limitations of his country.

There is no way in which these matters can be brought more clearly to the attention of the voter and farmer than by relating the experiences of other men in their struggles for existence. In nearly every State there are still to be made great and even fundamental changes in the laws relating to the control of water before the water resources can be fully utilized. The perplexities and even the mistakes of the pioneers teach most valuable lessons, for in many other States these conditions are not yet outgrown. Happy will their citizens be if they can utilize the costly experience of others without paying the high price.

LOCATION AND TOPOGRAPHY.

The State of Colorado comprises within its limits the headwaters of both the North and South Platte, the Arkansas, Rio Grande, San Juan, Grand, and White rivers. For convenience of water adminis-

tration, the State has been divided, as described on a later page, into six great divisions, corresponding to these large drainage basins indicated on the map (fig. 1) by roman numerals. These in turn have been divided into districts, and numbers have been arbitrarily assigned to these, as shown by the map. Of these districts, the one discussed in this paper is numbered 3, and includes Cache la Poudre Creek, one of the principal tributaries of South Platte River.

On the map the outlines of the water districts are indicated by light broken lines and those of the large divisions by heavy dotted lines. These latter follow the mountain summits or main divides, the line between divisions Nos. I and II and those to the west being

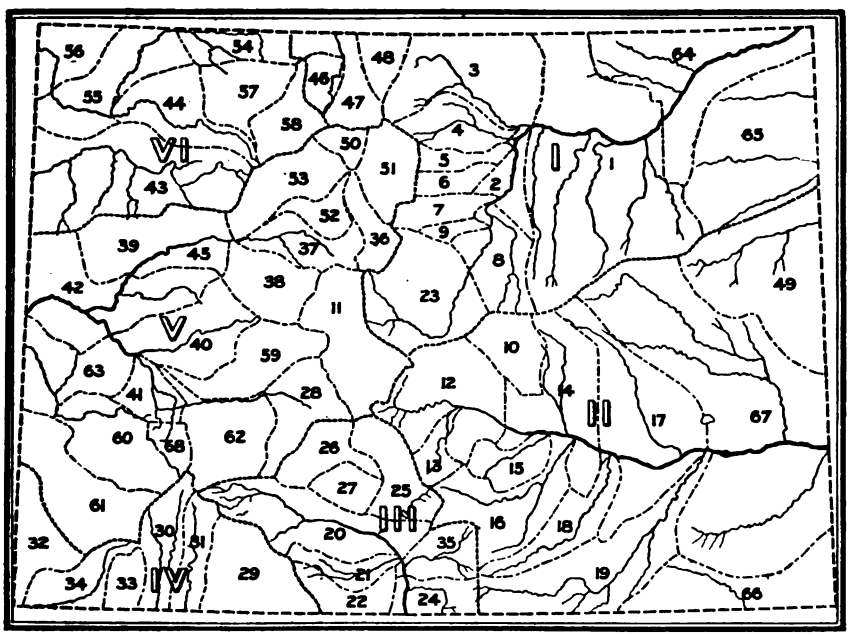


FIG. 1.—Map of water divisions and districts of Colorado.

along the continental watershed. This line thus marks the higher mountain ranges, which rise to altitudes of from 9,000 to over 13,000 feet. From these high crests the streams flow in all directions, those upon the east uniting to form the Arkansas, or, north of this, the South Platte. The latter stream, after debouching from its canyon some 12 miles south of Denver, pursues a nearly northerly course until it reaches Cache la Poudre Creek, some 52 miles by rail north of Denver and 4 miles east of Greeley. Near Denver it receives, from the mountains to the west, Clear Creek; 30 miles farther down, the St. Vrain; and 10 miles still farther, the Big Thompson. Cache la Poudre Creek is the last perennial tributary received by South Platte River before it joins the North Platte in Nebraska. The name,

originally Cache a la Poudre, signifies hiding place for the powder. In local usage it is often still further shortened to Poudre Creek.

These tributary streams above named head some 75 or 100 miles back of the foothills among mountain peaks many of which are over 14,000 feet high. Their flow is small during the seven months of the year commencing with September and ending with March. The discharge of the larger ones during these months rarely exceeds 100 second-feet or falls much below 50.

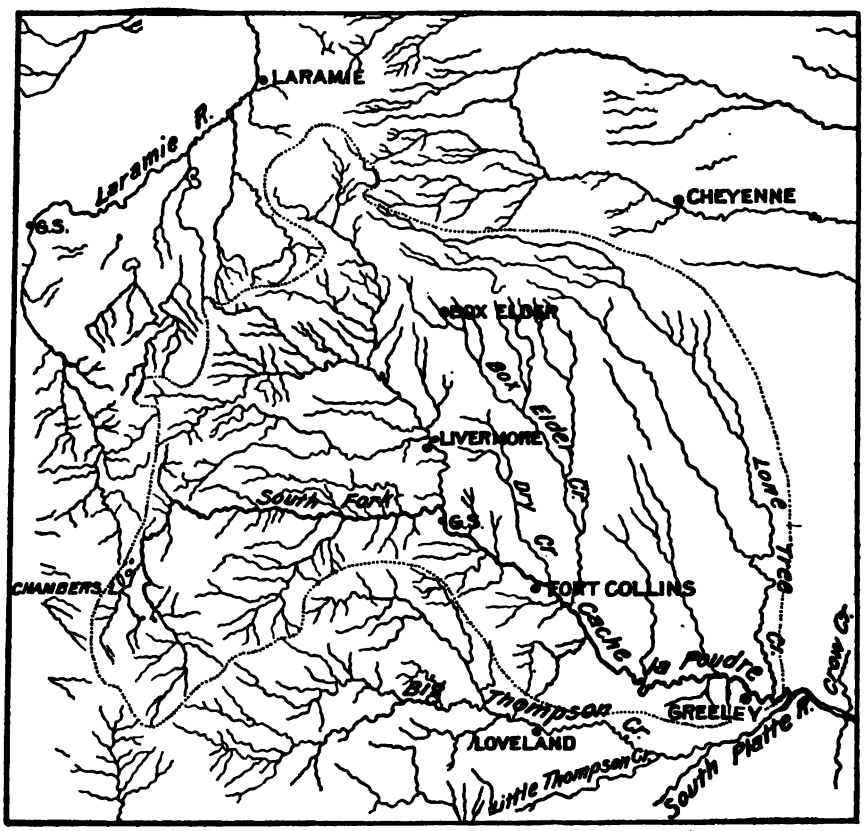


FIG. 2.—Map of Cache la Poudre Valley.

A small map, fig. 2, shows the principal streams and drainage channels tributary to Cache la Poudre Creek, and also exhibits the relative position of the towns. On the west the drainage basin extends well into the high mountains, from which a considerable proportion of the rain and snow falling upon the steeper slopes escapes to the stream. In the center of the basin is the belt of foothill region, and in the eastern third the undulating area, neither plain nor foothill. From this come a considerable number of drainage lines, the principal of which are Boxelder and Lone Tree creeks. These and other

channels rarely receive water. For the greater part of the year their beds, though well-marked features, are dry; but after heavy rains or unusual rain storms—locally known as "cloud-bursts"—they become filled with raging torrents, which destroy everything in their paths. The configuration of the country is such that the canals from the perennial streams must cross these, necessitating considerable expenditure in the construction of flumes or in annual outlay for repairs. A glance at the map of these channels and of the canal lines crossing them shows the well-marked trend toward the southeast and indicates that any excess or seepage water brought by the canals or by torrents, whether flowing above ground or percolating beneath, must ultimately reach Cache la Poudre Creek at points not far from its mouth.

The streams on the western side of the basin flow with rapid fall through narrow valleys. At the point marked on the small map (fig. 2) with a dot and the initials G. S. (gaging station) the river leaves the canyon and enters upon a comparatively broad valley. To the north of the stream the lands below this point are low, the bottoms varying in width from half a mile to 2 miles. Above these are in succession two or three well-defined terraces or benches, as they are sometimes called. The soil and subsoil of these are, as a rule, coarse and pervious, being composed largely of sands and gravels. On the south of the river the valley lands are narrow and restricted, comparatively small areas being available for agriculture.

The distance from La Porte, where Cache la Poudre Creek enters the foothills, to its junction with the Platte is about 32 miles as the railroad runs. It is some 8 miles from La Porte to the gaging station at the mouth of the canyon. From the canyon to Chambers Lake it is about 70 miles by the road as it winds among the mountains. This lake is near the head of the Middle Fork and is fed by a number of small streams, the altitude of the lake being about 9,000 feet.

RAINFALL.

The soils of the valley lands are, as a rule, fertile and adapted to the production of crops of the temperate zone; but the rainfall is usually deficient in amount, and can not be relied upon to supply sufficient moisture to the fields. Agriculture is therefore possible only by means of irrigation, which has been developed to a high degree of efficiency, although falling far short of ideal conditions. The amount of rainfall within the basin of Cache la Poudre Creek has been measured for only a comparatively short time and at a few places, these being at the towns in the lower part of the valley. To the northeast of the basin a series of measurements have been carried on at Cheyenne, Wyoming, and to the south observations have been had at a considerable number of points, these being mainly at the foothill towns.

The principal rainfall stations in geographic order from north to

south are as follows: Cheyenne, Wyoming; and Boxelder, Livermore, Fort Collins, and Loveland, Colorado. To the east of these latter is Greeley, at the lowest point in the valley. The locations of these places are shown on the small map (fig. 2). The mean annual rainfall at Cheyenne, the elevation of which is about 6,100 feet, has been from 1870 to 1896 a trifle over 12½ inches; the minimum rainfall, that of 1876, was 5.03 inches, and the maximum, that for 1883, was 19.24 inches. The distribution by years is shown on the accompanying diagram (fig. 3), which exhibits by the height of the black columns the quantity of rain for each year from 1870 to 1895, inclusive.

The record of precipitation at Boxelder is comparatively short, extending only from 1890. The average annual precipitation since that time has been a little less than 16 inches. At Livermore the record is fragmentary, the average from 1889 to 1893 being about 14 inches. At Fort Collins the record is longer, beginning in 1872, but

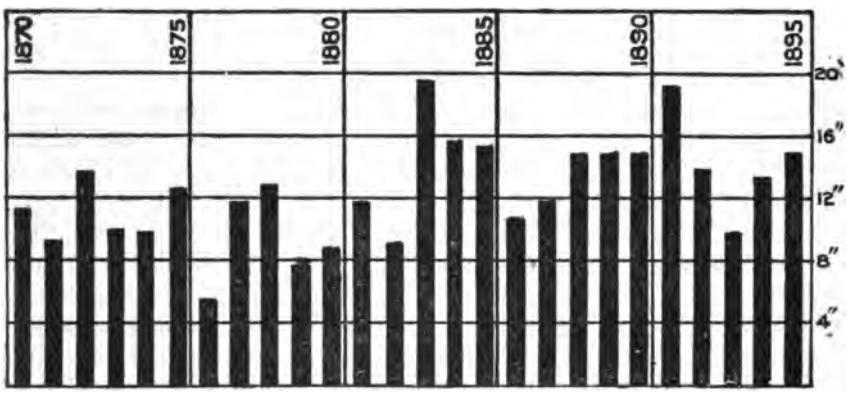
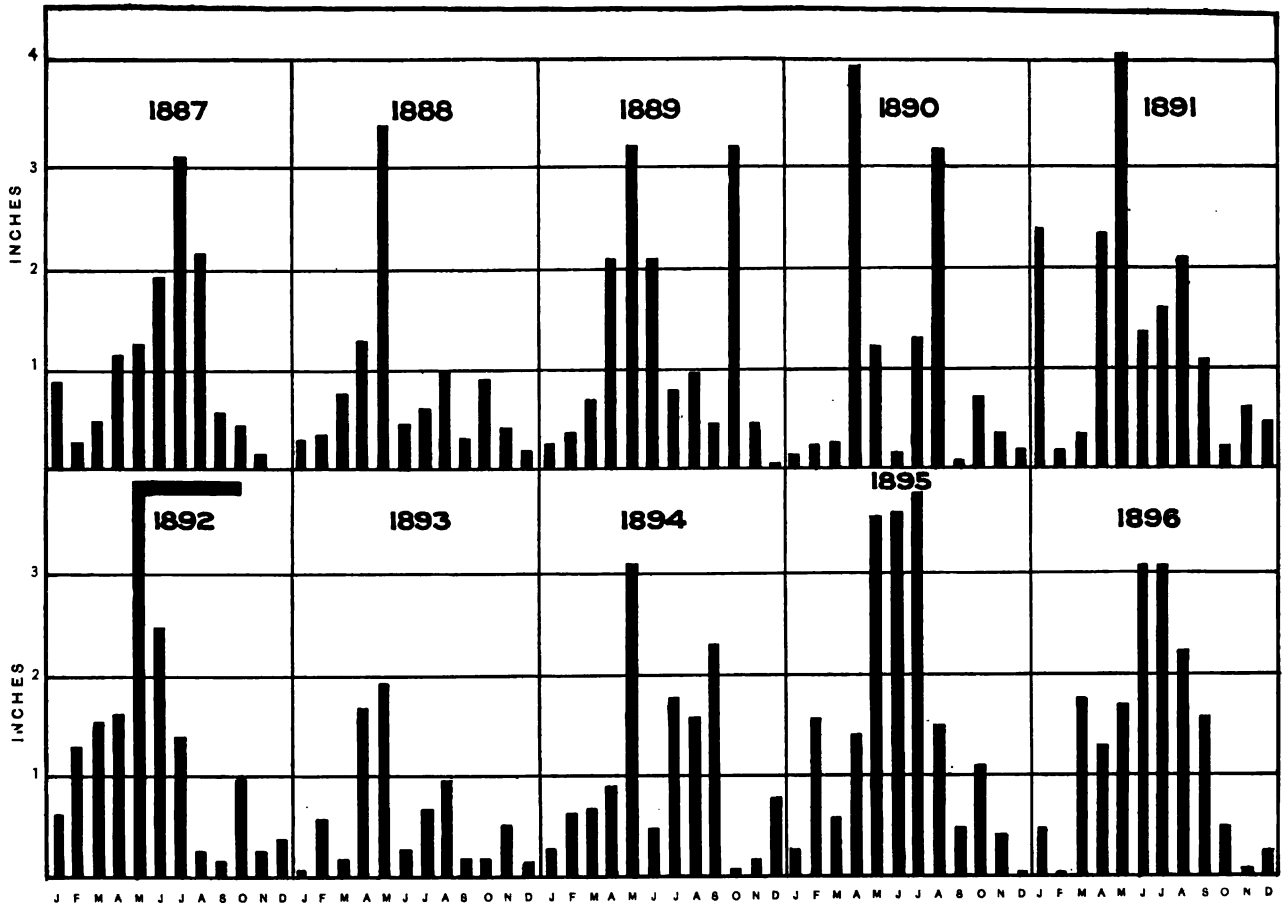


FIG. 3.—Diagram showing annual rainfall at Cheyenne, Wyoming.

is greatly broken until about 1887. The annual average has been 14 inches. The irregularity of distribution of the precipitation is well illustrated by the diagram in Pl. II, showing the monthly precipitation for the years 1887 to 1896, inclusive. This exhibits, by the height of each column, the total amount of rain occurring during the month, shown by the lettering at the top of the diagram. The greatest rainfall in any one month was that of May, 1892—4.83 inches. This diagram exhibits the usually heavy rainfall during the early summer and the prevailing winter drouths.

The record of rainfall at Loveland begins in 1887, being fragmentary until 1891. The average annual precipitation has been about 12 inches. At Greeley a less amount of rain is indicated, the average from 1887 being under 11 inches.

The following table allows a comparison since 1887 of the annual rainfall at the five points where the record is longest. The figures included in parentheses are those for which an interpolated value has


1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
INCHES
4
3
2
1
J F M A M J J A S O N D

been used for one or two missing months. The means given at the bottom of the table are not the averages of the figures above, but are the total of the monthly means, including thus portions of years otherwise defective:

Annual rainfall, in inches, within or near Cache la Poudre Basin.

Year.	Cheyenne.	Boxelder.	Fort Collins.	Loveland.	Greeley.
1887	(11.82)	.....	12.12	.....	.....
1888	14.51	.....	9.79	.....	.....
1889	14.65	.....	14.48	.....	14.58
1890	14.47	(11.71)	11.41	.....	.....
1891	18.97	20.45	17.50	.....	.....
1892	13.50	13.37	15.45	15.08	.....
1893	9.22	.....	7.06	7.03	5.04
1894	12.98	.....	12.36	10.77	5.93
1895	14.76	19.83	18.07	16.17	.....
1896	20.73	17.83	15.76	.....	13.52
Mean	12.62	15.88	14.09	12.18	10.71

The distribution of the rainfall by seasons is somewhat irregular, the greatest amount occurring during the months from April to August inclusive, nearly two-thirds of the total amount for the year falling at that time. This fact is illustrated by the following table showing the mean monthly precipitation at six important stations, the figures being obtained by averaging the records for all of the months during which observations were kept. In the column on the right these have again been averaged and computed in parts per hundred to still further illustrate the distribution by months; for example, the average of these records for the month of May, assuming that they all have equal weights, shows that 19.98 per cent of the total precipitation for the year has occurred during that month, or, in other words, one-fifth of the total amount of rain fell at that time. Next to this comes July with 13.08 per cent of the total precipitation of the year. Next in quantity of rain stand April and June, these being approximately equal.

Mean monthly precipitation at specified stations in Colorado.

Month.	Cheyenne.	Boxelder.	Livermore.	Fort Collins.	Loveland.	Greeley.	Per cent.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	
January	0.49	0.84	0.92	0.70	0.29	0.20	4.32
February	0.42	0.54	0.56	0.56	1.04	0.41	4.43
March	0.78	1.33	0.72	0.80	0.88	0.50	6.28
April	1.47	1.26	1.86	1.73	1.43	1.57	11.69
May	2.22	3.30	2.86	2.92	2.75	1.88	19.98
June	1.55	1.77	1.80	1.67	1.12	1.38	11.66
July	1.90	2.22	1.03	1.85	1.83	1.59	13.08
August	1.54	2.14	1.34	1.32	0.29	1.04	9.62
September	0.97	1.06	0.64	0.92	1.09	0.54	6.55
October	0.69	0.64	1.92	0.90	0.82	0.68	7.09
November	0.32	0.41	0.41	0.42	0.28	0.76	3.26
December	0.27	0.37	0.17	0.30	0.36	0.16	2.04
Total	12.62	15.88	14.23	14.09	12.18	10.71	100.00

WATER SUPPLY.

The principal source of water supply for the agricultural lands near Greeley is Cache la Poudre Creek, a comparatively small amount being derived from wells and from the impounded storm waters of intermittent tributaries. The main stream has been measured at the point where it leaves the canyon above Laporte, the observations having been continued for a longer number of years here than on any other stream in the arid region. The record therefore has a peculiar value, giving the fluctuations of discharge through a series of years. The position of the gaging station is shown on the small map (fig. 2) by the dot marked G. S. (gaging station). This is above nearly all of the irrigating canals and ditches, the principal exception being the North Poudre Canal, which irrigates about 4,000 acres, mainly in the valley of Boxelder Creek. The drainage area above the gaging station, as measured by planimeter on the Land Office maps of Colorado and Wyoming, is 1,060 square miles,[1] a region mainly mountainous in character.

By one of the provisions of an act of the general assembly of the State of Colorado, approved March 5, 1881, the office of State hydraulic engineer was created, and this officer was empowered to make measurements of the waters of streams used in irrigation. Under this act Mr. J. S. Greene was employed to make measurements of Cache la Poudre Creek, a station being established in Marsh Canyon.[2] From

[1] The area given in the second biennial report of the State engineer of Colorado, p. 91, is 972 square miles, as measured on Hayden's drainage map of Colorado.

[2] First report of the State engineer, Eugene K. Stimson, of Colorado, for the years 1881 and 1882. Denver, 1882, p. 16.

his measurements computations were made of the daily discharge from June 20 to August 5. It was found, however, that the act was defective, and further measurements could not be made until a remedy was provided. During 1882, therefore, no further attempt was made to ascertain the flow of the stream.

Early in 1883 a site for a gaging station was selected on what was known as McBride's preemption, about one-half mile above the mouth of the canyon and 12 miles above Fort Collins. The bowlders were removed by blasting, and the channel was cleared out and straightened as well as was found possible with small expenditure. Gage readings were continued during the irrigation season, and occasional measurements were made of the velocity by means of an eight-vaned Fteley meter, manufactured by Buff & Berger, the instrument being provided with an electrical registering device. After the completion of work at the river station all of the ditches taking water from Cache la Poudre Creek in which measuring flumes had been built were examined and computations were made as to their capacities at various heights of water.

In the fall of 1883, after the river had subsided, a remeasurement was made of the cross section of the channel, and it was found that this had changed so greatly as to vitiate the original computations, although these had value as approximations. Propositions were made to the ditch owners taking water from this river that they furnish the necessary funds to build a permanent measuring flume where a self-recording nilometer could be installed. By volunteer contributions the sum of $1,650 was obtained and used in the construction of a measuring flume and small house for sheltering the instrument. These preparations were completed in November, 1883. In March of the following year the nilometer was placed in position and measurements of velocity were begun. It was found necessary to use for this purpose a stouter instrument, as the stream was of the character of a torrent, carrying at times a considerable amount of drift. The instrument devised, known as the Colorado current meter, has been in successful operation for many years in the turbulent waters of that State.[1]

The record was continued through the season of 1885 and 1886.[2] It was noted at that time that the river has, in common with all mountain streams, a daily variation quite marked from the first of May to the last of October. This is due to the rapid melting of the snow in mountains under the influence of the sun during the daytime and the cessation of such melting at night. The greatest variation amounted to about 8 inches, or a difference of 1,500 second-feet.

[1] Second Biennial Report of the State Engineer of Colorado (E. S. Nettleton), for the years 1883 and 1884, pp. 6-8. The daily discharge was computed from March 15 to October 16, 1884. The results are shown on pp. 84-91. Those for 1883 were not printed.

[2] Third Biennial Report of the State Engineer of Colorado (E. S. Nettleton), for the years 1885 and 1886, pp. 55-57. The daily discharge was computed from April 14 to October 10, 1885, and from April 27 to October 17, 1886, pp. 62-68.

During May the point of maximum discharge was reached about 4 a. m. and the minimum about 7 p. m., the time becoming later as the season advanced. By the last of July the maximum flow was at 1 p. m. and the minimum at 3 a. m. Occasional storms also increase the volume of the stream rapidly, that on the night of May 20, 1884, causing it to increase in volume from 3,153 second-feet to 6,848 second-feet in eight hours. On August 18, 1884, the river rose a height of nearly 5½ feet in thirty minutes, subsiding almost as quickly.

The results of the measurements and computations made during 1887 and 1888 were not given numerically, but are expressed graphically.[1] For the succeeding years, 1889 and 1890, the station was maintained in part by the Division of Hydrography of the United States Geological Survey. About that time the station was found to be in poor condition, the plank flooring, resting on piling, having become bulged and

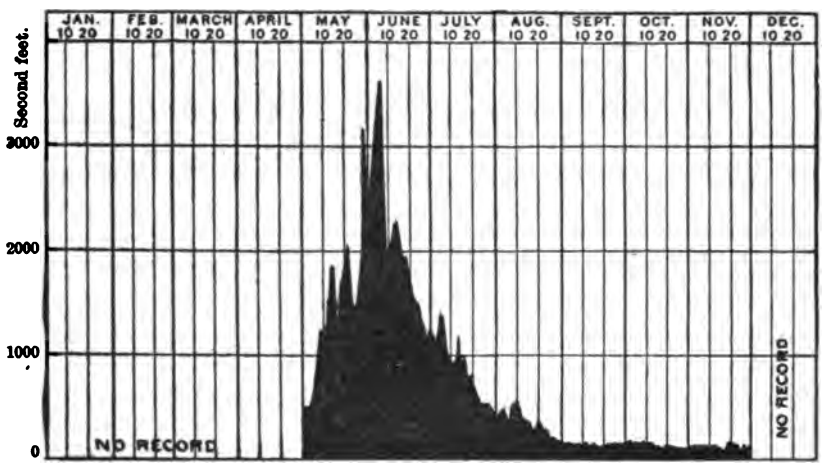


FIG. 4.—Diagram showing daily discharge of Cache la Poudre Creek for 1894.

rotted, so as to necessitate its removal. The walls of timber and plank gave way, resulting in gradual change of the cross section. Thus the results did not possess the accuracy possible while the section was in good order.[2]

On June 9, 1891, a heavy flood in the river, occasioned by the breaking of Chambers Lake dam, destroyed the registering apparatus belonging to the State of Colorado, and another instrument was substituted by Prof. L. G. Carpenter, of the Agricultural College at Fort Collins.[3]

[1] Fourth Biennial Report of the State Engineer of Colorado (J. S. Greene) for the years 1887 and 1888, in two parts: Pl. XV.

[2] Fifth Biennial Report of the State Engineer of Colorado (J. P. Maxwell) for the years 1889 and 1890. The results of computations of daily discharge for 1889 are given on page 22 and those for 1890 on page 23.

[3] Sixth Biennial Report of the State Engineer of Colorado (J. P. Maxwell) for the years 1891 and 1892, p. 18. Results of the computations of daily discharge for 1891 are given on page 22, and those for 1892 on page 23. Also, see Colorado Agricultural Experiment Station Bulletin No. 22, Preliminary report on the duty of water, L. G. Carpenter, p. 22.

During 1893 and 1894 the flow of water was reported at the weir in the canyon by the automatic register. The results are given in the progress report of the Division of Hydrography.[1]

During the succeeding years, 1895–96, occasional measurements were made under the direction of Professor Carpenter, but the results have not been made public.

DAILY MEAN DISCHARGE OF CACHE LA POUDRE CREEK.

The following tables of daily mean discharge of Cache la Poudre Creek have been arranged by months for convenience of comparison of the amount flowing in different years. The figures have been obtained from the following sources:

1881. First Biennial Report of the State Engineer, p. 16. Discharge computed from June 20 to August 5, 1881.

1882. No measurements were made during this year.

1883. Figures not published, but found in manuscript in the office of the State engineer. The discharges from March 23 to May 3, 1883, are only approximate, being obtained by interpolation, assuming that the cross section did not change. From May 4 to July 4, 1883, the discharges are deduced from gage reading and are claimed to be close approximations. From July 4 to August 20 the amount of decrease was assumed to be two-thirds of the amount of decrease per day from July 20 to August 20.

1884. Second Biennial Report of the State Engineer of Colorado, pp. 6–8, 84–91. Discharge computed from March 15 to October 16, 1884. Figures are also given in the Third Biennial Report, on pages 61 to 67.

1885. Third Biennial Report of the State Engineer, pp. 62–68. Discharge computed from April 14 to October 10, 1885.

1886. Third Biennial Report of the State Engineer, pp. 62–68. Discharge computed from April 27 to October 17, 1886.

1887. Fourth Biennial Report of the State Engineer. Figures not published. Diagram on Pl. XV. Discharges shown from March 18 to October 23, 1887.

1888. Fourth Biennial Report of the State Engineer. Figures not published. Diagram on Pl. XV. Discharges shown from March 14 to October 23, 1888.

1889. Fifth Biennial Report of the State Engineer, p. 22. Discharge computed from January 1 to December 31, 1889.

1890. Fifth Biennial Report of the State Engineer, p. 23. Discharge computed from January 1 to December 31, 1890.

1891. Sixth Biennial Report of the State Engineer. Discharge computed from January 1 to December 31, 1891.

1892. Sixth Biennial Report of the State Engineer, p. 23. Discharge computed from January 1 to April 17, and from May 18 to August 16, 1892.

1893. Progress Report, Bulletin United States Geological Survey, No. 131, p. 31. Computations from May 11 to August 31, 189[illegible]

1894. Progress Report, Bulletin United S[illegible]eological Survey, No. 131, p. 31. Computations from May 2 to November 30, 189[illegible].

1895. Progress Report, Bulletin United States Geological Survey, No. 140, p. 112. Mean monthly discharge only.

1896. Preliminary figures for May and June. By L. G. Carpenter.

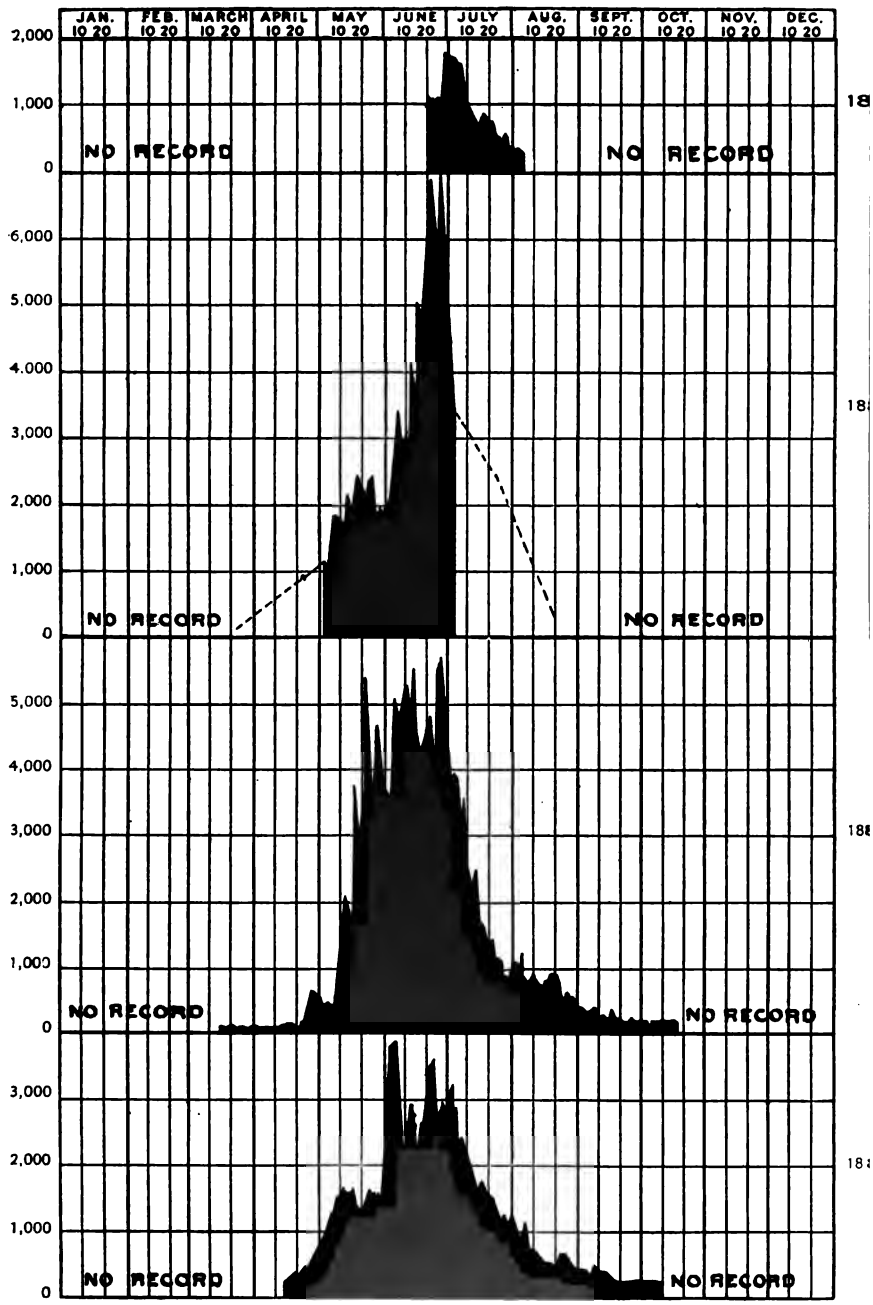
[1] United States Geological Survey Bulletin No. 131. Report of progress of the Division of Hydrography for the calendar years 1893 and 1894, p. 31.

Estimated daily discharge, in second-feet, of Cache la Poudre Creek for the months of January and February.

Day.	January.				February.			
	1889.	1890.	1891.	1892.	1889.	1890.	1891.	1892.
1	71	45	86	70	73	104	131	98
2	130	65	83	65	75	133	118	98
3	130	69	61	54	86	137	109	98
4	89	78	50	50	101	133	100	104
5	111	101	50	52	98	104	89	104
6	115	101	46	52	92	78	83	104
7	98	83	44	50	92	75	66	112
8	83	75	46	54	122	75	63	104
9	108	59	52	60	133	89	66	112
10	98	78	52	60	130	107	66	112
11	134	86	66	60	108	104	68	122
12	173	98	76	60	111	98	68	122
13	193	104	76	58	101	86	68	115
14	193	101	78	58	75	78	66	128
15	183	101	86	54	69	73	66	128
16	173	101	109	50	71	85	57	128
17	164	78	109	50	83	75	57	128
18	168	78	112	54	108	73	57	128
19	243	81	145	56	75	69	57	134
20	306	78	131	63	89	49	59	125
21	324	75	131	72	101	43	66	112
22	342	78	131	72	101	52	71	109
23	255	83	145	72	134	49	73	109
24	164	92	131	72	150	37	68	112
25	146	73	131	72	198	49	83	112
26	118	73	141	72	198	44	86	128
27	89	78	115	72	173	52	86	128
28	118	83	83	72	142	69	83	134
29	108	89	88	83	.....	.....	.....	128
30	98	87	88	92	.....	.....	.....	.....
31	73	78	109	98	.....	.....	.....	.....
Average	155	82	92	64	110	79	76	116

Estimated daily discharge, in second-feet, of Cache la Poudre Creek for the month of March.

Day.	1883.	1884.	1888.	1889.	1890.	1891.	1892.
1	.....	.....	.....	125	89	70	128
2	.....	.....	.....	104	104	63	134
3	.....	.....	.....	86	101	59	134
4	.....	.....	.....	78	92	52	128
5	.....	.....	.....	73	78	50	122
6	.....	.....	.....	58	71	50	106
7	.....	.....	.....	55	67	55	98
8	.....	.....	.....	55	65	71	92
9	.....	.....	.....	52	71	73	94
10	.....	.....	.....	52	58	68	60
11	.....	.....	.....	40	49	66	60
12	.....	.....	.....	41	47	66	62
13	.....	.....	.....	41	52	61	72
14	.....	.....	110	41	52	55	72
15	.....	73	100	41	60	52	72



DIAGRAMS OF DAILY DISCHARGE OF CACHE LA POUDRE CREEK FOR 1881, 1883, 1884, AND 1885.

Estimated daily discharge, in second-feet, of Cache la Poudre Creek for the month of March—Continued.

Day.	1883.	1884.	1888.	1889.	1890.	1891.	1892.
16	.....	71	100	42	85	52	72
17	.....	67	110	44	104	54	40
18	.....	62	120	47	101	54	60
19	.....	64	150	44	101	57	72
20	.....	78	110	43	101	63	72
21	.....	92	110	43	101	73	72
22	.....	48	120	47	107	76	72
23	107	64	130	48	125	73	72
24	133	70	150	46	114	70	72
25	159	72	140	46	104	66	67
26	185	76	120	43	101	57	50
27	211	67	90	43	98	52	50
28	237	55	110	43	98	46	50
29	263	50	150	44	85	42	50
30	289	63	130	47	78	40	50
31	315	75	130	55	78	32	56
Average	211	68	120	54	85	59	78

Estimated daily discharge, in second-feet, of Cache la Poudre Creek for the month of April.

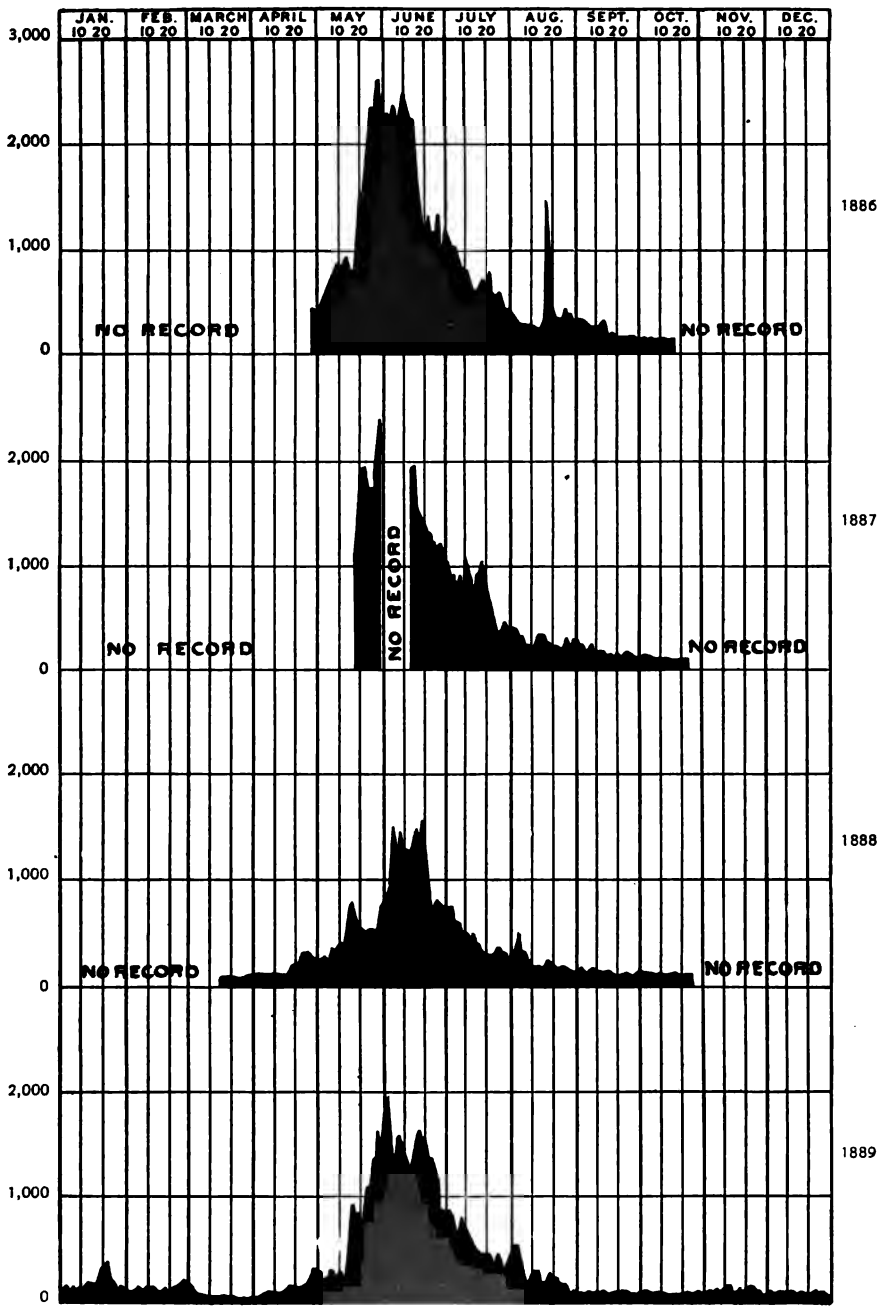
Day.	1883.	1884.	1885.	1886.	1888.	1889.	1890.	1891.	1892.
1	341	92	.....	.....	120	48	73	39	60
2	367	76	.....	.....	110	48	71	50	67
3	393	74	.....	.....	100	52	69	59	60
4	419	71	.....	.....	100	57	71	48	60
5	445	70	.....	.....	110	58	73	48	72
6	471	68	.....	.....	100	65	92	54	72
7	497	65	.....	.....	100	71	107	59	72
8	523	71	.....	.....	110	78	101	75	72
9	549	78	.....	.....	110	75	98	86	84
10	576	78	.....	.....	100	68	89	97	92
11	601	83	.....	.....	110	59	98	109	98
12	627	93	.....	.....	100	59	107	109	98
13	653	125	.....	.....	100	65	122	103	98
14	678	115	241	.....	100	70	137	81	98
15	705	120	250	.....	110	68	137	71	98
16	731	129	274	.....	120	73	133	68	112
17	757	122	284	.....	130	88	133	78	112
18	783	189	314	.....	160	129	141	134	.....
19	809	176	336	.....	170	122	178	166	.....
20	835	174	358	.....	190	101	237	166	.....
21	861	177	447	.....	220	101	243	159	.....
22	887	201	410	.....	330	101	271	159	.....
23	913	186	441	.....	350	101	300	194	.....
24	941	279	398	.....	330	107	336	214	.....
25	967	439	505	.....	340	146	455	258	.....
26	993	585	559	.....	350	198	474	296	.....
27	1,019	708	609	447	330	237	481	338	.....
28	1,045	702	624	416	310	288	435	323	.....
29	1,071	666	732	387	270	342	372	323	.....
30	1,097	602	822	369	260	312	366	344	.....
Average	718	219	447	405	181	113	200	144	84

Estimated daily discharge, in second-feet, of Cache la Poudre Creek for the month of May.

Day.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.
1	1,111	501	954	404	.....	250	283	435	355	.....	.....	.....
2	1,149	453	1,029	466	.....	270	237	494	394	.....	.....	492
3	1,174	496	1,067	525	.....	290	214	552	441	.....	.....	481
4	1,049	521	1,165	581	.....	250	237	666	565	.....	.....	483
5	1,042	477	1,186	617	.....	280	282	764	806	.....	.....	572
6	1,352	508	1,237	654	.....	370	348	722	1,053	.....	.....	663
7	1,580	521	1,279	724	.....	390	324	633	1,160	.....	.....	793
8	1,848	671	1,258	772	.....	310	237	666	1,239	.....	.....	1,057
9	1,829	965	1,465	873	.....	330	237	729	1,179	.....	.....	1,299
10	1,707	1,387	1,488	900	.....	390	300	743	1,044	.....	.....	1,208
11	1,716	1,845	1,592	873	.....	400	254	800	823	.....	217	1,246
12	1,776	2,067	1,522	937	.....	350	254	836	908	.....	344	1,321
13	2,192	1,978	1,522	908	.....	360	397	800	710	.....	278	1,453
14	1,988	1,793	1,522	882	.....	460	736	729	766	.....	308	1,538
15	1,848	1,897	1,534	848	.....	550	903	736	710	.....	.....	1,829
16	1,942	3,491	1,557	805	.....	740	947	807	970	.....	.....	1,838
17	2,172	3,738	1,499	816	.....	790	888	888	1,092	.....	.....	1,355
18	2,399	3,576	1,420	937	1,150	650	851	1,078	1,130	276	.....	1,315
19	2,325	3,022	1,279	1,186	1,620	610	807	1,109	1,208	282	.....	1,697
20	2,201	3,375	1,290	1,465	1,910	550	736	1,186	1,250	278	.....	1,842
21	2,104	5,398	1,333	1,534	1,950	540	822	1,388	1,312	270	1,047	2,051
22	2,289	4,289	1,465	1,836	1,910	490	1,055	1,592	1,355	292	1,043	1,779
23	2,339	3,933	1,545	1,914	1,680	520	1,062	1,461	1,409	388	920	1,585
24	2,355	3,695	1,592	2,045	1,840	530	1,086	1,405	1,858	570	841	1,302
25	2,092	3,609	1,523	2,195	1,810	550	1,147	1,469	2,499	618	870	1,483
26	1,914	3,828	1,534	2,407	1,820	560	1,380	1,583	2,273	847	974	1,650
27	1,776	4,382	1,476	2,378	2,000	560	1,364	1,651	2,173	1,067	876	1,817
28	1,838	4,610	1,522	2,599	2,100	530	1,642	1,710	1,979	1,084	812	1,984
29	1,997	4,215	1,498	2,660	2,380	610	1,486	1,650	2,018	1,067	878	2,151
30	1,808	3,757	1,664	2,584	.....	750	1,477	1,510	2,044	1,075	1,107	2,318
31	1,928	3,637	1,965	2,250	.....	770	1,886	1,575	.....	872	929	2,485
Av.	1,833	2,536	1,419	1,308	1,847	484	770	1,044	1,224	642	763	1,390

Estimated daily discharge, in second-feet, of Cache la Poudre Creek for the month of June.

Day.	1881.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.
1	.....	2,035	3,474	2,378	2,349	.....	880	1,960	1,736	2,005	750	.....	2,652
2	.....	2,091	3,598	3,355	2,307	.....	1,090	1,608	1,804	1,979	786	.....	2,820
3	.....	2,273	3,996	3,815	2,349	.....	1,350	1,502	1,625	1,790	1,112	.....	3,046
4	.....	2,400	4,493	3,815	2,422	.....	1,490	1,323	1,510	1,542	1,415	1,230	3,206
5	.....	2,468	4,835	3,858	2,392	.....	1,370	1,282	1,339	1,634	1,002	1,108	3,461
6	.....	2,802	5,064	3,390	2,264	.....	1,250	1,559	1,225	1,840	960	1,041	3,672
7	.....	3,050	4,914	2,706	2,293	.....	1,250	1,583	1,139	1,902	1,084	1,197	3,514
8	.....	3,386	4,785	2,335	2,407	.....	1,410	1,486	1,178	2,436	1,260	1,767	2,782
9	.....	3,050	4,854	2,236	2,509	.....	1,170	1,502	1,193	5,060	1,468	2,198	2,094
10	.....	2,830	5,196	2,236	2,584	.....	1,220	1,388	1,217	3,600	1,636	2,667	1,908
11	.....	3,067	5,177	2,614	2,509	.....	1,200	1,298	1,201	3,065	1,522	2,912	2,067
12	.....	4,142	4,894	2,989	2,378	.....	1,210	1,258	1,186	2,635	1,260	2,949	2,236
13	.....	3,771	5,135	2,925	2,278	.....	1,190	1,298	1,242	2,190	1,114	2,252	2,346
14	.....	3,688	5,459	2,799	2,278	1,970	1,260	1,307	1,225	1,860	1,200	.....	2,291
15	.....	4,183	5,248	2,524	1,993	1,970	1,420	1,559	1,282	1,728	1,457	.....	2,104
16	.....	5,006	4,720	2,293	1,784	1,770	1,450	1,608	1,315	1,624	1,360	.....	2,027



DIAGRAMS OF DAILY DISCHARGE OF CACHE LA POUDRE CREEK FOR 1886, 1887, 1888, AND 1889.

Estimated daily discharge, in second-feet, of Cache la Poudre Creek for the month of June—Continued.

Day.	1881.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.
17	.....	4,783	4,553	2,321	1,704	1,590	1,320	1,486	1,331	1,501	1,658	.....	1,791
18	.....	4,798	4,318	2,599	1,580	1,520	1,360	1,518	1,339	1,373	1,444	2,386	1,915
19	.....	5,097	4,421	2,675	1,454	1,480	1,550	1,534	1,298	1,752	1,645	2,483	1,717
20	1,104	6,008	4,720	2,907	1,420	1,430	1,290	1,486	1,266	1,579	1,579	2,427	1,586
21	1,053	6,293	4,833	3,338	1,376	1,360	1,050	1,315	1,266	1,545	2,535	2,274	1,452
22	1,053	7,292	4,723	3,407	1,322	1,360	920	1,307	1,258	1,479	2,450	1,905	1,458
23	1,037	7,292	4,259	3,529	1,227	1,250	650	1,242	1,282	1,534	2,285	1,758	1,427
24	1,078	6,748	4,838	3,287	1,237	1,250	730	1,178	1,225	1,545	2,312	1,616	1,375
25	1,095	6,402	5,159	3,055	1,250	1,190	780	1,062	1,201	1,848	2,178	1,422	1,250
26	1,092	5,893	5,404	2,675	1,387	1,250	750	1,016	1,163	1,579	2,165	1,354	1,216
27	1,074	6,924	5,530	2,799	1,398	1,250	750	948	1,155	1,260	1,564	1,246	1,228
28	1,727	6,566	5,611	2,969	1,311	1,080	680	874	1,139	1,049	1,445	1,244	1,120
29	1,681	6,058	5,415	2,799	1,258	1,050	690	837	1,062	1,076	1,392	1,177	1,065
30	1,640	5,723	4,747	2,675	1,247	1,050	680	837	1,016	985	1,332	1,132	1,067
Average	1,239	4,539	4,812	2,911	1,876	1,401	1,114	1,339	1,280	1,900	1,512	1,815	2,063

Estimated daily discharge, in second-feet, of Cache la Poudre Creek for the month of July.

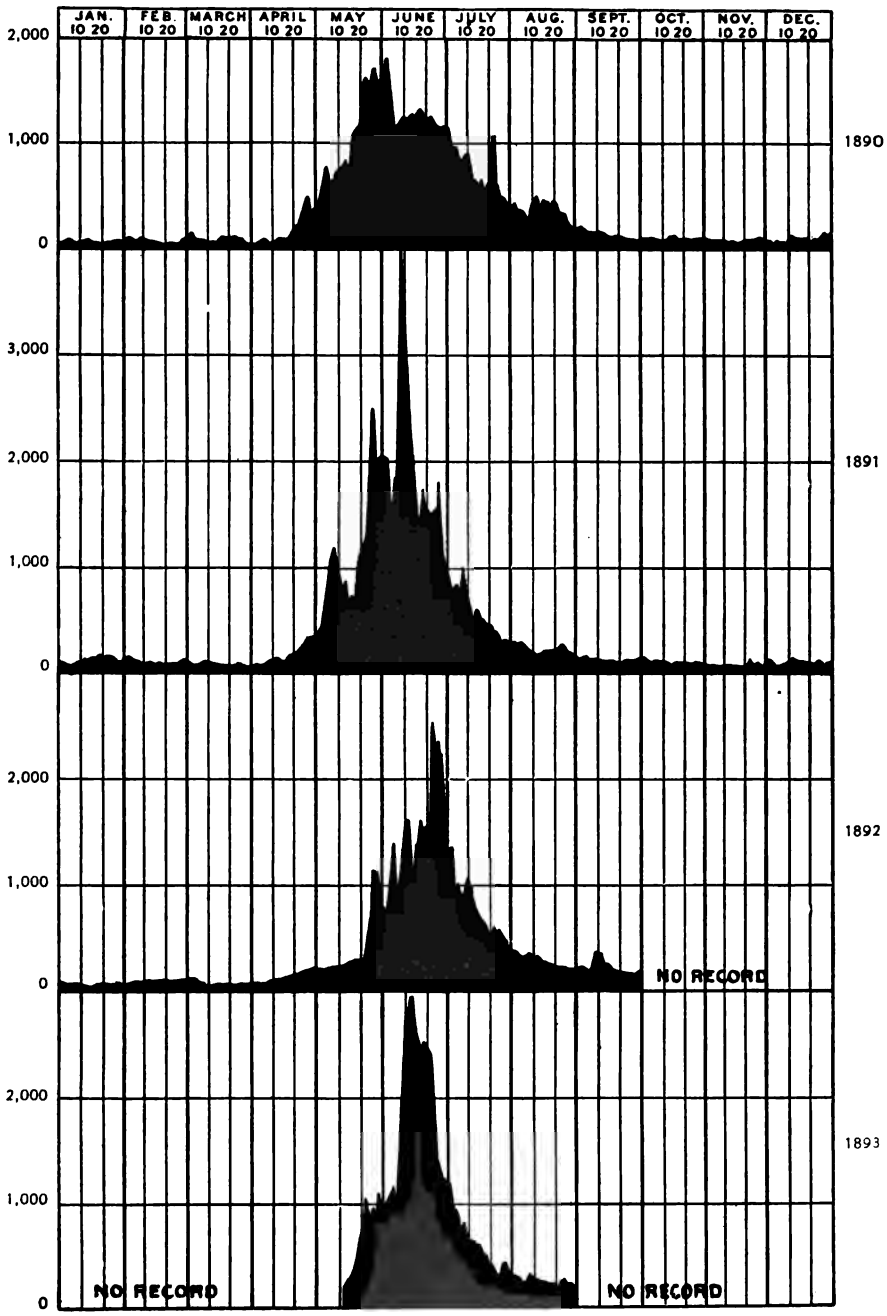
Day.	1881.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.
1	1,622	5,082	3,852	3,055	1,176	980	670	844	970	784	1,392	1,144	1,109
2	1,600	4,447	3,970	3,186	1,126	900	690	844	963	849	1,340	1,038	1,082
3	1,600	3,988	3,845	2,878	1,057	920	610	779	957	864	870	996	1,109
4	1,582	3,395	3,848	2,830	1,038	880	560	722	896	824	1,020	997	1,278
5	1,510	3,344	3,459	2,830	1,038	720	550	633	852	768	993	947	1,234
6	1,507	3,294	3,309	2,321	972	700	540	579	822	832	950	795	1,158
7	1,393	3,243	3,581	2,349	927	700	490	680	764	1,003	908	840	1,078
8	1,203	3,193	3,572	2,378	873	880	560	757	736	907	984	838	956
9	1,084	3,143	3,180	2,208	839	700	510	757	857	768	1,084	744	925
10	963	3,092	2,575	2,181	831	1,260	490	736	770	699	1,000	693	925
11	853	3,042	2,360	2,019	764	890	470	653	712	626	960	663	923
12	786	2,992	2,218	1,939	700	830	450	599	601	558	857	678	936
13	740	2,941	2,305	1,888	685	740	510	546	590	531	822	661	1,177
14	680	2,891	2,458	1,784	639	710	420	513	546	524	784	602	878
15	635	2,840	1,933	1,688	609	940	410	461	613	512	736	608	982
16	673	2,790	1,753	1,712	602	960	350	435	533	492	698	576	899
17	845	2,739	1,755	1,762	609	960	330	416	481	462	648	526	782
18	823	2,689	1,622	1,676	692	1,060	320	397	515	432	639	511	817
19	814	2,639	1,522	1,652	707	890	310	385	559	426	564	476	820
20	713	2,588	1,428	1,557	669	810	290	366	559	415	530	454	728
21	715	2,513	1,462	1,522	764	710	280	354	1,000	392	584	401	696
22	585	2,438	1,196	1,476	566	580	300	294	1,023	381	558	384	647
23	522	2,362	1,194	1,398	552	510	350	378	613	354	512	359	602
24	547	2,287	1,145	1,258	545	490	390	360	502	322	538	348	567
25	481	2,211	1,123	1,176	588	420	380	336	448	302	498	353	561
26	564	2,136	982	1,206	539	420	340	312	403	283	443	444	567
27	528	2,061	955	1,176	466	410	320	265	403	278	402	463	553
28	484	1,985	903	1,076	441	490	310	271	360	288	396	406	522
29	396	1,910	862	1,155	410	450	310	306	348	307	380	383	497
30	376	1,834	1,026	1,145	404	440	260	416	336	307	348	354	461
31	361	1,759	1,063	1,076	393	450	270	448	366	298	342	343	444
Average	877	2,834	2,144	1,860	717	735	421	511	648	542	735	614	836

Estimated daily discharge, in second-feet, of Cache la Poudre Creek for the month of August.

Day.	1881.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.
1	343	1,683	1,068	1,057	369	430	390	455	360	292	327	336	479
2	350	1,608	1,022	1,029	309	410	500	435	342	284	322	343	494
3	337	1,533	1,120	972	299	400	380	403	324	273	307	321	512
4	319	1,457	1,231	918	289	380	310	306	294	269	293	282	440
5	302	1,382	863	937	279	350	300	249	255	289	272	256	379
6	.....	1,306	849	1,116	264	330	280	209	222	251	268	251	396
7	.....	1,231	820	1,019	255	320	240	159	183	233	288	251	513
8	.....	1,157	772	856	255	260	220	146	173	212	271	293	487
9	.....	1,081	860	788	255	250	190	183	198	200	302	327	477
10	.....	1,006	934	772	250	220	180	231	336	200	288	298	464
11	.....	930	860	740	241	230	180	237	403	192	251	.....	427
12	.....	855	804	685	237	360	190	220	348	184	232	.....	393
13	.....	780	780	624	232	370	180	188	354	180	202	.....	362
14	.....	704	796	595	232	380	170	146	403	173	228	.....	365
15	.....	629	788	552	237	380	150	137	397	208	202	.....	369
16	.....	553	827	518	237	350	220	137	385	225	192	.....	347
17	.....	478	833	479	289	320	250	133	385	220	.....	.....	319
18	.....	403	916	466	1,476	280	210	154	306	233	.....	.....	298
19	.....	327	925	460	479	250	220	225	383	238	.....	239	295
20	.....	250	922	441	416	240	210	193	366	238	.....	189	282
21	.....	.....	800	559	343	250	160	178	348	242	.....	226	278
22	.....	.....	683	566	314	230	150	150	294	269	.....	218	271
23	.....	.....	590	559	294	220	160	146	271	288	.....	248	274
24	.....	.....	625	545	274	250	150	141	282	273	.....	219	240
25	.....	.....	653	518	416	320	150	141	251	229	.....	191	229
26	.....	.....	603	491	387	280	150	111	238	229	.....	161	212
27	.....	.....	625	466	342	260	140	98	234	220	.....	155	204
28	.....	.....	594	441	347	250	140	86	183	217	.....	158	179
29	.....	.....	511	416	325	320	140	81	178	192	.....	158	182
30	.....	.....	443	398	279	320	140	67	159	173	.....	141	165
31	.....	.....	423	369	264	320	140	71	150	155	.....	151	162
Average	330	968	792	657	338	307	213	188	290	228	265	235	175

Estimated daily discharge, in second-feet, of Cache la Poudre Creek for the month of September.

Day.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1894.
1	446	347	264	300	160	73	159	148	171
2	390	325	274	290	180	73	173	151	182
3	369	309	274	250	140	73	183	155	178
4	350	299	284	230	130	69	159	158	179
5	361	294	255	220	120	67	150	151	161
6	364	299	232	200	120	67	138	134	152
7	397	337	223	220	120	67	130	131	140
8	410	387	215	270	130	71	130	138	227
9	360	387	215	190	150	65	122	138	296
10	318	358	215	180	140	59	111	138	281
11	302	342	210	170	120	58	108	138	276
12	314	325	210	170	110	56	101	138	246
13	294	314	198	160	110	58	98	138	219
14	271	274	177	150	110	60	89	128	178



DIAGRAMS OF DAILY DISCHARGE OF CACHE LA POUDRE CREEK FOR 1890, 1891, 1892, AND 1893.

Estimated daily discharge, in second-feet, of Cache la Poudre Creek, etc.—Cont'd.

Day.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1894.
15	313	255	169	140	110	69	85	125	165
16	375	246	162	140	120	73	85	125	155
17	319	241	158	130	110	73	85	125	157
18	280	232	162	120	90	71	81	122	152
19	255	223	177	130	80	73	81	118	146
20	239	218	143	140	80	73	86	115	135
21	233	218	136	120	80	73	89	138	118
22	231	218	122	110	80	75	92	138	113
23	237	218	115	120	90	73	78	138	108
24	269	218	122	140	90	73	73	141	105
25	260	218	130	180	80	70	73	141	108
26	246	210	136	170	80	68	73	141	107
27	245	210	147	160	70	71	73	141	101
28	240	218	143	150	80	71	73	148	99
29	235	218	140	150	100	69	65	151	132
30	230	215	136	140	110	67	58	151	145
Average	305	272	185	175	108	69	103	138	164

Estimated daily discharge, in second-feet, of Cache la Poudre Creek for the month of October.

Day.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1894.
1	225	210	133	120	100	71	57	151	144
2	212	206	133	150	110	73	55	148	158
3	203	202	140	150	90	69	55	145	135
4	197	202	130	140	100	69	58	128	141
5	203	202	133	130	110	71	60	131	118
6	199	202	133	110	100	71	73	134	146
7	199	202	130	110	100	67	73	141	151
8	212	202	133	120	110	61	73	134	143
9	209	202	133	130	100	56	73	122	128
10	215	206	130	120	100	55	73	115	131
11	202	.....	127	130	110	56	67	112	120
12	202	.....	122	120	100	60	89	112	107
13	197	.....	120	120	100	69	118	112	99
14	200	.....	120	110	110	68	118	112	94
15	200	.....	120	120	120	69	118	112	93
16	196	.....	122	130	100	65	101	112	93
17	.....	.....	130	150	120	65	80	115	93
18	.....	.....	.....	140	130	67	81	122	93
19	.....	.....	.....	150	120	69	81	112	89
20	.....	.....	.....	150	130	75	83	112	97
21	.....	.....	.....	140	100	73	83	112	82
22	.....	.....	.....	140	120	71	71	112	85
23	.....	.....	.....	150	130	69	73	115	87
24	.....	.....	.....	.....	.....	69	78	112	84
25	.....	.....	.....	.....	.....	69	78	109	84
26	.....	.....	.....	.....	.....	71	78	106	84
27	.....	.....	.....	.....	.....	73	89	107	78
28	.....	.....	.....	.....	.....	75	89	106	74
29	.....	.....	.....	.....	.....	86	89	104	71
30	.....	.....	.....	.....	.....	85	89	104	71
31	.....	.....	.....	.....	.....	92	92	104	78
Average	204	204	129	130	109	70	80	118	105

Estimated daily discharge, in second-feet, of Cache la Poudre Creek for the months of November and December.

Day.	November—				December—		
	1889.	1890.	1891.	1894.	1889.	1890.	1891.
1	92	89	100	79	69	67	84
2	71	83	98	91	78	60	95
3	75	81	98	96	67	61	72
4	86	78	95	.....	55	55	54
5	69	69	84	.....	56	52	60
6	71	67	84	.....	60	67	72
7	73	71	77	91	60	46	72
8	92	73	72	95	65	52	77
9	111	71	72	96	65	48	77
10	122	68	77	93	60	50	82
11	122	58	82	89	48	107	109
12	98	55	82	94	73	80	100
13	85	49	87	85	73	71	100
14	86	52	84	80	78	65	100
15	101	44	79	85	89	58	98
16	98	39	67	77	86	60	100
17	107	41	72	42	33	63	92
18	107	42	72	116	89	67	74
19	111	43	70	150	73	53	72
20	101	52	82	146	67	55	72
21	101	55	100	115	61	44	72
22	92	61	95	107	55	67	72
23	98	63	84	60	58	67	74
24	89	69	84	57	73	58	92
25	67	61	82	103	61	55	87
26	58	65	87	90	71	60	56
27	45	73	84	92	81	71	56
28	56	55	84	91	67	83	72
29	65	53	82	89	43	101	72
30	73	63	84	93	41	86	72
31	.....	.....	.....	.....	39	101	72
Average	87	61	83	83	64	65	79

Estimated mean monthly discharge of Cache la Poudre Creek from 1881 to 1894.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1881	------	------	------	------	------	*a* 1,239	877	*b* 330	------	------	------	------
1883	------	------	*c* 211	718	1,833	4,539	2,834	*d* 968	------	------	------	------
1884	------	------	*e* 68	219	2,536	4,812	2,144	792	305	*f* 204	------	------
1885	------	------	------	*g* 447	1,419	2,911	1,860	657	272	*h* 204	------	------
1886	------	------	------	*i* 405	1,308	1,876	717	338	185	*j* 129	------	------
1887	------	------	------	------	*k* 1,847	*l* 1,401	735	307	175	*m* 130	------	------
1888	------	------	*n* 120	181	484	1,114	421	213	103	*o* 109	------	------
1889	155	110	54	113	770	1,339	511	188	69	70	87	64
1890	82	79	85	200	1,044	1,280	648	290	103	80	61	65
1891	92	76	59	144	1,224	1,900	542	228	138	118	83	79
1892	64	116	78	*p* 84	*q* 642	1,512	735	*r* 265	------	------	------	------
1893	------	------	------	------	*s* 763	*t* 1,815	614	*u* 235	------	------	------	------
1894	------	------	------	------	1,390	2,063	836	175	164	105	83	------

a June 20-30, 1881.
b August 1-5, 1881.
c March 23-31, 1883.
d August 1-20, 1883.
e March 15-31, 1884.
f October 1-16, 1884.
g April 14-30, 1885.
h October 1-10, 1885.
i April 27-30, 1886.
j October 1-17, 1886.
k May 18-29, 1887.
l June 14-30, 1887.
m October 1-23, 1887.
n March 14-31, 1888.
o October 1-23, 1888.
p April 1-17, 1892.
q May 18-31, 1892.
r August 1-16, 1892.
s May 11-14 and 21-31, 1893.
t June 4-13 and 18-30, 1893.
u August 1-10 and 19-31, 1893.

SETTLEMENT IN CACHE LA POUDRE VALLEY.

During his tour in Colorado, in 1859, Horace Greeley was impressed with the belief that the higher lands were adapted to cultivation if irrigated. On his return to New York he discussed the matter, and with the cooperation of N. C. Meeker gave the proposition great publicity. The colony plan presented through the columns of the Tribune culminated in 1870 in the formation of Union Colony, which, settling in Cache la Poudre Valley, gave to their town the name of Greeley.[1]

When the colony arrived, it found a few settlers in the valley, who had occupied the bottom land mostly for the pasture and wild hay it offered. They had taken out from the Cache la Poudre Creek a number of small canals, which had in cultivation under them, as near as can be ascertained, about 1,000 acres. They generally believed that the higher bench land lacked fertility, and that it was extremely unwise on the part of the colony people to construct canals for its irrigation.

UNION COLONY.

Union Colony, under the leadership of N. C. Meeker and the auspices of Horace Greeley, undertook, in the spring of 1870, the settlement of the lower end of Cache la Poudre Valley, the headquarters being upon the site of Greeley. The leaders of the colony constructed, as quickly as possible after their arrival, a ditch on the south side of the creek, on the site of the one that now irrigates the lots in town and

[1] Second Biennial Report of the State Engineer of Colorado for the years 1883-84, p. 20.

the lands in its vicinity. There were only some 200 acres put into crops, but the ditch was small and poorly constructed, and without a dam at its head in the river to divert the low water into it, so that not enough water could be obtained for this small area.

This first ditch demonstrated the great fertility of the soil when sufficiently moist to enable vegetation to avail itself of its plant food. The original cost was $6,333. It was enlarged three times, in 1871, 1872, and 1873, and then cost in all, with dam, about $25,000. It has

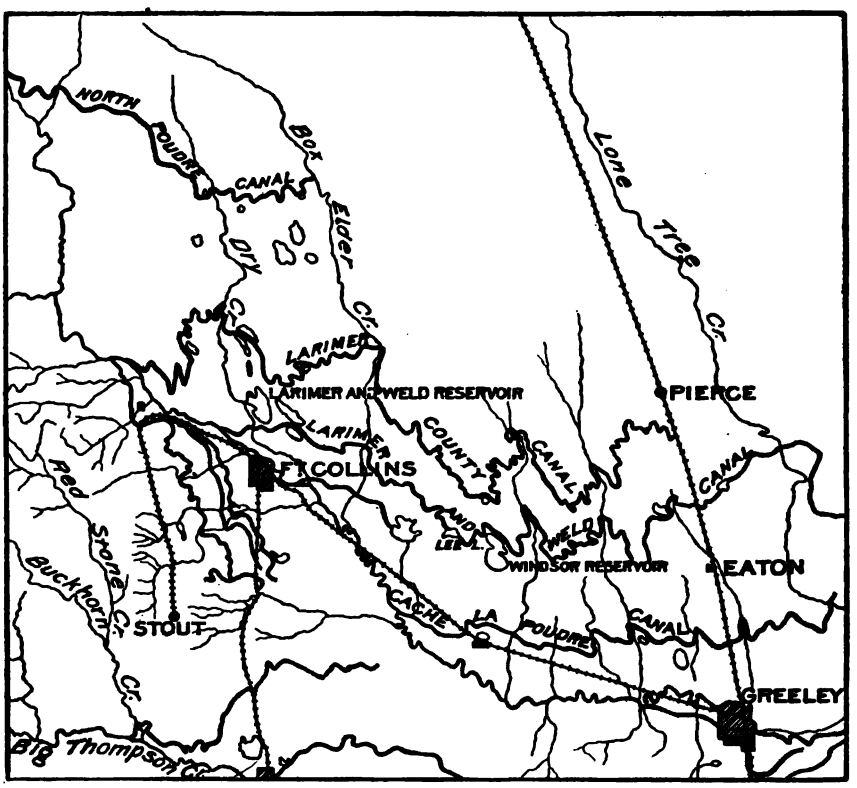


FIG. 5.—Map of canals near Greeley, Colorado.

a capacity, by the decree of the court, of 173 second-feet. In 1894, as shown by a table in the State engineer's report, it is credited with having only 1,275 acres under irrigation, of which 480 are reported as pasture and waste land. This, no doubt, leaves out of account the town lots irrigated from this canal, which have a probable area of 300 acres. The insignificance of the area thus reported as under cultivation shows that if this had been all the colony would have been a failure as an agricultural community, and there was no other industry for it in this locality to pursue.

CANAL AND RESERVOIR SYSTEMS.

A number of canal systems were projected by Union Colony, the first of these, or No. 1, never begun, being planned to head in the canyon above La Porte and terminate at Crow Creek, covering nearly all of the lands later watered by the two canals known as the Larimer County and the Larimer and Weld County canals. Canal No. 2, later known as Cache la Poudre Canal, was begun during the fall of 1870.[1] Canal No. 3 was the town ditch described above. No. 4 was to come out of Big Thompson Creek and water the lands on the bluff south of Greeley, now irrigated by the Loveland and Greeley Canal. Thus canals Nos. 2 and 3 were the only ones constructed under the original plans of the colonists.

A list of the most important canals and ditches is given on page 51 in connection with the crop statistics of this district. The location of the three largest is shown on the accompanying map (fig. 5) and a general description of them is given below. These, in geographic order, are Cache la Poudre Canal, immediately north of the city of Greeley; above this Larimer and Weld Canal; and still above, and in a general way parallel, Larimer County Canal. Still further to the northwest is also shown on this small map the lower end of North Poudre Canal, belonging to the North Poudre Land, Canal, and Reservoir Company, and described on page 58.

CACHE LA POUDRE CANAL.

The survey of what was originally known as Canal No. 2 was prosecuted during the summer of 1870, and the construction of its whole length—35 miles—was practically completed during the autumn of that year and the spring of 1871. It was supposed to be in shape to deliver an abundance of water to all the crops that could be got in under it for irrigation during the summer of 1872. Some 2,000 acres were put in crops, but most of them were burned up for want of water. It was a year of scarce supply, there was no dam in the river, and the head of the canal ran for a mile and a half along the edge of a slough upon which its lower bank rested, and this bank soon settled so that it could not hold the passing water. This loss of crops by the most enterprising and courageous colonists—men of moderate means—came near paralyzing the whole enterprise.

During the fall of 1871 and spring of 1872 an enlargement was made and a dam put in the river. The cost of the first construction was about $27,000 and of the enlargement $20,000 more. This year the river had an ample supply, and the spring was moist, and hence favorable for plowing and the germination of seeds. The result was an area planted of some 6,000 acres and fine crops. However, the canal was yet quite too small for the 25,000 acres of land under it

[1] History of Greeley and the Union Colony of Colorado, by David Boyd, 1890.

owned by colonists, and two other enlargements were made in 1874 and 1877, making the total cost up to that date about $87,000.

The Cache la Poudre Canal—originally Union Colony Canal No. 2—was the earliest of the large systems. It was for a long time deemed unnecessary to supplement its river supply by a reservoir. However, it was found that in more than one-half the years the river water gave out before the potato crop was made, and that the farmers under it were at a disadvantage as compared with those who had

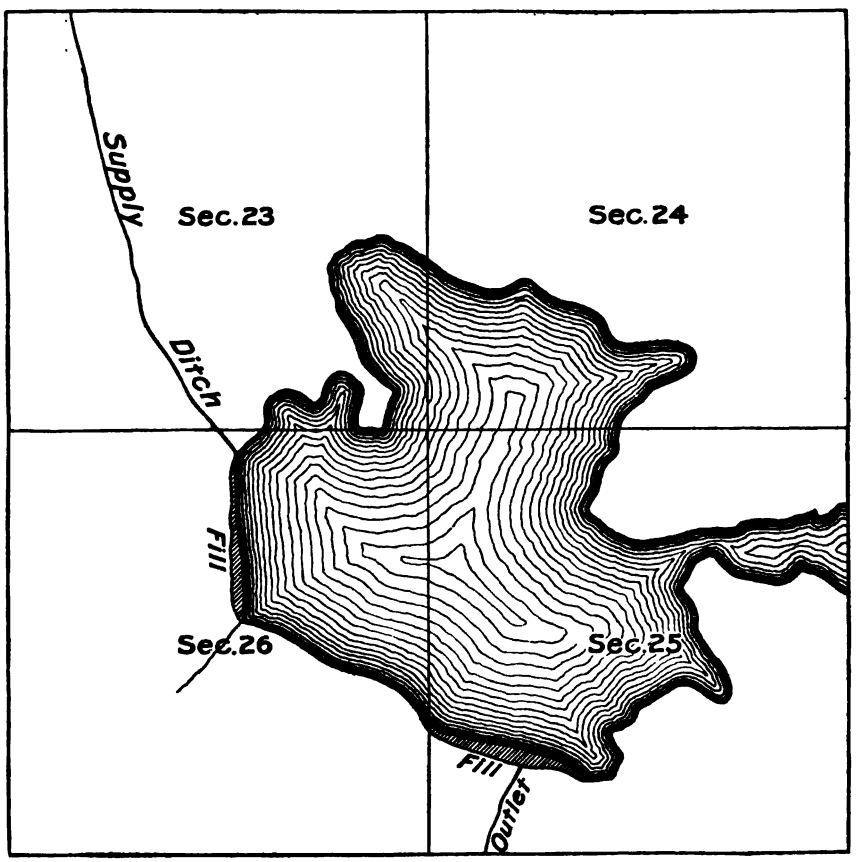


FIG. 6.—Map of Cache la Poudre Reservoir.

water from the Larimer and Weld Reservoir, the contents of which were used for the potato crop in 1891. In 1892 the farmers under the Cache la Poudre Canal commenced to take steps toward building a reservoir. They found a site (shown in fig. 6) about 4 miles above their canal, the contents of which could be emptied into it about 2 miles below its head, and could be filled by constructing a feeding canal some 8 miles long and heading in the river just below the tail-race of the Linden Flouring Mills, which enters the river at Fort Collins.

These mills have an early appropriation from the river, dating back to 1867, for 93 cubic feet per second. As this claim antedates the adoption of the constitution of the State by 9 years, the courts have decided that the provision in that instrument giving claims for water for irrigation purposes a superior right to those for mechanical purposes does not apply in this and similar cases. Hence the water of the river must be run to the head-gates of the mill canal, however low the river is, except for the use of the few canals that antedate it and whose heads are above the mill tailrace. Since none of the water is consumed in furnishing power to the mills, it does not affect canals below it. There is nominally a claim for 401 second-feet prior to its claim, but the heads of more than half of the ditches making the claim are below its tailrace and many of the others have been abandoned. The most important claim above its tailrace is that of 19 second-feet by the Larimer and Weld Canal, but this only antedates it for irrigation purposes; for storage purposes its reservoirs rest on their own date, which is 25 years later than that of the mills. The Pleasant Valley and Lake Canal also has a claim of 40 feet antedating that of the mills, and this heads above the mill power canal, and hence as long as irrigation lasts can take the water, and does in the autumn, when it is scarce, to the detriment of the mills. The same is true of Dry Creek Ditch to the extent of an appropriation of 12 second-feet.

While irrigation lasts these three claims greatly disturb the mill supply when the river is low, early in spring and late in autumn, and hence its proprietors put in steam power to use when water is scarce. Should they abandon the use of the water altogether, an interesting question will be raised concerning the legal rights of the Cache la Poudre Reservoir to the water which the position of its head-gates in the river just below the tailrace now allows it to store to the extent of what runs through the mill race, in spite of the fact that its claims to water for storage purposes postdate nearly all the other important reservoirs. These are all supplied by canals that head above the tailrace, and nearly all—and at times all—the winter supply of the river must be allowed to flow by for the mill, and hence for the sole benefit of the reservoir we are considering. The main reason for locating the head of their reservoir supply canal where it is was to obtain this very water, and now, if the mill should abandon its use, who would have the right to it? Should it be turned back into the river and be subject to the appropriation already made, or should this reservoir continue to enjoy the privilege?

Cache la Poudre Canal has been conveyed by Union Colony for a nominal sum to a new company, composed of the farmers owning the land and water rights under the canal. The new owners have expended about $25,000 in straightening the course of the canal (shown in Pl. VI), constructing permanent dam and head works, and putting in checks at the head of nearly every lateral. These were needed because the slope of 3.2 feet per mile was too steep for a canal

of this size and resulted in erosion of the bed and lowering of the channel. The head works are of stone masonry laid in cement. The gates are of iron, and each is constructed of an upper and lower section, only one of which is moved when the head at the gates is high, less power being thus required for lifting.

The duty of water under Cache la Poudre Canal has been computed by Prof. L. G. Carpenter.[1] The length of time during which this canal has been in operation and the consequent long experience of farmers render the measurements of considerable value for comparative purposes. The amount of water taken into the canal was measured daily or estimated from a record kept by an automatic register. The results given in the following table show a comparatively large duty if a long season is taken, but, on the contrary, for the month of June alone, when water is in abundance, the average duty drops off rapidly, falling to from 65 to 95 acres per second-foot.

Duty of water under Cache la Poudre Canal in acres per second-foot.

Period.	Days.	1890.	1891.	1892.
May 1 to September 1	123	132	153	112
April 1 to September 1	153	164	192	146
May 1 to November 1	184	198	232	176
June alone	30	72	95	65

The total cost of the canal has been $112,000. There are some 300 80-acre water rights held in the canal and represented by a share of stock for every 10 acres. Each is entitled to a proportionate share of the water in the canal at all stages. It will be seen that the average cost of an 80-acre right in the canal was $373⅓. Such rights, when the land under them has become so wet as not to need irrigation, have been selling to parties owning lands lately taken up at the lower end of the canal for $2,000 apiece. This price does not include a right to water from the reservoir, which is owned by another company, although most of its stock is held by the parties who own the canal. Rights to 80 acres in this reservoir were sold in 1896 for $800 apiece. Placing the cost of the reservoir at $120,000 and the number of rights at 300, the cost per right would be $400, apparently giving a profit of 100 per cent on the investment. Of course in all such enterprises for a while the capital invested is unproductive. In this case the period was not long, since the work was prosecuted with vigor, the reservoir being fit for use one year after its commencement. Those not owning land have generally been able to rent their reservoir rights at a fair interest on the investment.

[1] Colorado Agricultural Experiment Station Bulletin No. 22, Preliminary Report on the Duty of Water, pp. 18-21.

VIEW OF GREELEY CANAL NO. 2; NEARLY EMPTY.

CACHE LA POUDRE RESERVOIR.

This is the most expensive of all the reservoirs in the valley. In the argument before the court the cost is placed at $125,000. The statement obtained from the company gives $28,643 for real estate for site of reservoir and right of way of supply canal, 8 miles long (capacity, 150 second-feet), and outlet canal, 4 miles long (capacity, 200 feet per second); also $81,623 for construction, making a total cost of $110,266. It has by far the longest and highest embankment of any of the reservoirs in the valley. At the outlet this embankment is 38 feet high, the height of water above the bottom being 30 feet. The breadth of the base at this place is 300 feet. The inside face has a slope of more than 3 to 1, and still the riprapping slides down each year on account of the action of the waves. When first laid it had a uniform slope from top to bottom, but now the slope is quite irregular, through the action of the waves moving the rocks and washing away the embankment under them. This is of good material, being largely composed of coarse gravel brought from a hill near one end by wheel scrapers. The rock for riprapping was brought from the foothills by rail to the nearest point, which is 2 miles off, and thence by wagon. It cost per ton, laid down, $110. It is medium-sized, flat sandstone, the refuse of the quarries where building and flagging stones are taken out.

The conduit is but a few feet deep below the level of the natural surface, the material of its foundation being a tenacious clay. The base is of wide flagstone laid on a grout bedding of gravel, sand, and Portland cement. The width is 5 feet inside, walls 2½ feet high, spanned by an arch 2½ feet high in center. There are two collar walls extending from the masonry of the conduit into the embankment, to prevent the water from working its way along the connection of the earth and masonry. It has shown no signs of weakness at this place, but when the reservoir is full the embankment gets quite soft throughout. However, it yearly gets less so. It settled 4 to 5 feet the first year after the water was turned in, although the teams had traversed it back and forth with wheel scrapers bringing the gravel and earth from the ends of the fill.

The gates and means of raising them are a novelty, the invention of Mr. Gordon Land. The front of the inlet of the conduit is a steep inclined plane, some 20° from the vertical. The aperture is divided into two sections by a timber running midway up and down in the plane of the incline, and on the outer edges of it are fastened iron plates of about the weight of wagon tire. A similar timber and tire are on each side of the aperture, thus forming a double track for two iron gates. These latter are each attached to two axletrees which

have wheels at their extremities and are brought to bear upon the track when the gates are being raised.

This is done by means of a wire rope, one end of which is attached to a cog-geared windlass placed on the top of the embankment and the other end to a lever attached to the axle of the gate, which axle is eccentric, so that the movement of the lever causes the wheels to bear on the tracks and to roll along it, instead of having the edges of the gate drag over the edges of the supports behind it, as in raising the ordinary gate. Each rope passes over a pulley placed at the top of the incline. It should be further said that the axle and wheels are attached to the upper and outer sides of the gates, and the front and rear axles are yoked together so that the rope acts on both and presses their attached wheels against the tracks in lifting the gates.

The cost of this reservoir equals that of the canal of which it is an adjunct. It furnishes only 5,654 acre-feet, while during the irrigation season of 1894 the canal drew from the river 70,610 acre-feet, or more than twelve times as much. Hence it is to be said that reservoir water is costly.

At present prices of farm produce it certainly does not pay to store water at this cost. Storage reservoirs, even of the most economical location, can not as a general rule be profitably employed in irrigation, except as adjuncts to canals that have for the most part their supply from a fairly permanent source during the irrigation season. None of the streams in this State except those of the western slope hold out in the latter part of the season so as to furnish water enough to complete the growth of certain crops, save for a few claimants of early rights. The one crop in this valley for which there is need of later water than the streams afford is potatoes. Up to 1895 this crop has been on an average profitable, even though we have been forced to seek a wider market than that of the plains and Rocky Mountain region. Hence the late development of reservoir construction in this valley.

It will be further noted that when a canal is already built, with all its laterals and means of distribution, and a reservoir can be constructed so as to deliver its water into it near enough to the head to supply the greater part of its customers, the case is very different from that of building a reservoir that has to provide all the means necessary for the distribution of its contents. This is the case of nearly all of the reservoirs in this valley. When that can not be done, the exchanges noted on another page effect the same economy so far as they can be brought into practice. When, however, the relation of the reservoir to the canal is like that of the one we are considering, it gives an independence and certainty not to be found where the use of the water by its owners depends upon so many contingencies.

As stated on a preceding page, the feeding canal for this reservoir

VIEW OF DAM AND HEAD GATES OF LARIMER AND WELD CANAL, POUDRE VALLEY

heads in the river immediately below the tailrace of the Linden Mills, at Fort Collins. This location was made for the purpose of securing the water from this mill, as intimated above. The destruction of the mill has given rise to one of the most perplexing questions in regard to water rights. The mill in its use of water power has proved a great detriment to the irrigation of the valley, since in order to turn its wheels it has been necessary to allow the water to pass the head gates of all the canals feeding reservoirs except this one. The other parties in interest would undoubtedly have purchased the rights of the mill and turned the water back into the river to be used for storage in the order of its appropriation were it not for the claim of vested rights made by this lower reservoir.

Recurring to the value of this reservoir as an investment, it may be said that in spite of the comparatively early appropriation of water by the canal it would not be possible without it to obtain in two years out of three sufficient water for the potato crop. The number of sacks of potatoes produced under this canal in 1894 was 602,485. During that year the crop sacked was worth, on an average, 70 cents per hundredweight. Deducting 5 cents for the cost of the sack and 10 cents for harvesting, the net value is 55 cents. The seed and labor cost the same amount for a half as for a whole crop. We may set down to the credit of the reservoir one-half of this crop, which at 55 cents per hundredweight amounts to $165,683, or a third more than the cost of the reservoir. That, however, was an exceptional year, both as to product and price. It would be fair to estimate the average crop under this canal at 500,000 hundredweight, and the average price at 40 cents per hundredweight. Allowing one-half the crop as due to the reservoir water, this would amount to $62,500, or one-half the cost of the reservoir.

LARIMER AND WELD CANAL.

The Larimer and Weld Canal takes water from Cache la Poudre Creek above Fort Collins and about 12 miles above the head of Cache la Poudre Canal. The total length is stated to be 50 miles, and the average bottom width 25 feet. Water is diverted by a wing-crib dam 177 feet long and 4 feet above the bed of the stream.[1] The dam and head gates are shown in Pl. VII. This canal has under it one-third of all the land under ditch in the valley and has a capacity greater by one-fourth than that of any other. It can take in the average flow of the whole river except during the 60 days commencing with the middle of May. In Pl. VIII is given a view looking up the canal to the headgates. Before its final enlargement, which was, in fact, its real construction, there was nominally appropriated 2,735.87 cubic feet per second, this being more than the average flow of the river for any one month. The older canals could not use so much water as this, but

[1] Report on Agriculture by Irrigation at the Eleventh Census. F. H. Newell, 1894, p. 135.

could take so much that during years of scarcity this canal could at no time receive a full head. Every year the supply fell to its second appropriation of 19 feet before the time to irrigate potatoes, which up to 1895 was the best-paying crop.

LARIMER AND WELD RESERVOIR.

An excellent site for a reservoir was found at a point a mile and a half north of Fort Collins, about a quarter of a mile above the canal and only 2 miles from its head. This could be supplied from two small canals above the Larimer and Weld, the bottom of the reservoir being only 2 feet above that of the canal. This site is a natural basin, in which, when filled to the lip of the lower rim, the surface of the water would be 25 feet above the bottom of the outlet, and which, it is estimated, would contain 350,000,000 cubic feet or 7,700 acre-feet. The canal company did not wish to undertake this work, but permitted the farmers who held contracts for water from it to take the site which it had surveyed. These farmers represented water rights covering 15,000 acres. They formed a company known as the Larimer and Weld Reservoir Company, proceeded to condemn the site and procure the means of feeding it.

The following are the principal items of expense and relate to construction to hold a depth of 25 feet:

Surveying and engineering	$2,870
Land and rights for water	13,768
Construction	21,796
Attorneys' fees	5,796
Court expenses	2,312
Miscellaneous	18,240
Total	64,782

It will be seen that only about one-third the expenses was for construction, not including surveying and engineering. In fact, no considerable embankment had to be made for that depth. An inlet canal was of necessity built from Dry Creek, which was its feeder, this in turn being supplied by two small canals in which a right of carriage had been purchased. The expenses of construction were increased from the fact that a wooden conduit was put in at first. The parties living under the reservoir deemed it unsafe. This necessitated its removal and the substitution of a cement and rock conduit, costing about $5,000. The quantity of land originally purchased was some 700 acres. This, with the right to run water through the inlet ditches, cost about one-fifth of the whole.

In 1895 the company resolved to increase the capacity to a depth of 30 feet. This required the construction of a bank over 2,000 feet long on the top, and this, with the additional land to be purchased, added to the cost $25,000 more, making the total cost about $90,000. This

VIEW OF HEAD GATES OF LARIMER AND WELD CANAL AND OF THE CANAL BELOW THEM.

addition of 5 feet to the upper surface increased the cubic contents by one-half. However, in being measured out over a weir, the reservoir does not come up to the estimated capacity by one-third. In fact, on drawing the water down from a depth of 29⅓ feet to 4 feet a content of only 325,000,000 cubic feet was given. This discrepancy between the capacity estimated from depth and contour, and measured as above, is true of all other reservoirs in this valley that have been tested in the same way. The weirs are not constructed so that the Francis formula will apply to them, but they are rated by a current meter at different depths, just as the weirs in the canals are measured to find their intake from the river.

The accompanying views, Pls. IX, X, XI, illustrate the embankment and outlet of this reservoir. The first (Pl. IX) is a view from the inside of the reservoir after the water has been drawn off. The rectangular mass of masonry in the center is the wall of the well which surrounds the space where the gates are placed. Its interior dimensions are 6 feet by 10 feet. The wall is 3 feet thick and is composed of heavy rubble masonry laid in Portland cement and connected with flanking walls.

The next view (Pl. X) shows the lower side of the outlet of the reservoir. In the middle is the heavy lower retaining wall, extending only a portion of the way up the embankment. The latter was constructed of earth, with a slope of 1½ to 1. At the right are posts standing at various angles. These were driven into the ground to keep the earth from slipping into the canal below the masonry, as it was tending to do after becoming moistened by percolation from the water in the reservoir. The next view (Pl. XI) is at the lower end of the outlet canal of the reservoir where it discharges over the weir into the Larimer and Weld Canal.

On account of the exchanges which are being made for river water it will be apparent that a high degree of accuracy of measurement is desirable, or at least that the same system of measurement should obtain in measuring the outflow of the reservoirs and the intake of canals, and this is attempted; but those who have studied and experimented most on measuring water under ordinary and diverse conditions best know how difficult it is to obtain accurate results.

The large expenditure in litigation was brought about by the fact that after the reservoir had been constructed by the farmers the canal company refused to allow them to run the reservoir water in the canal. The farmers had contracts with the company to furnish them so much water, but they were not stockholders in the company. The contracts also provided that the holders of these contracts should become stockholders after the company had sold water rights to the estimated capacity of the canal to furnish water. But this limit, which was 500 eighty-acre water rights, had not been reached, and moreover these same farmers had gone into the courts asking an injunction

prohibiting the company from selling any more than the 370 rights that then had been sold, since there was a provision in the contracts that in times of scarcity the water was to be prorated with all the rights sold and in force. It was contended that the company had sold more than it could furnish, this word applying equally to the water to be obtained from the river and to the capacity of the canal to carry.

This case has been in court some five years. The company won in the district court and in the court of appeals, while these decisions were reversed in the State supreme court, which sent the case back for trial again in district court, which gave the farmers their case, as instructed by the upper court. However, there seemed to be another appeal to the supreme court, the company meantime being restrained from selling any more water rights until the case is finally adjudicated. The expenses of this case, as well as that concerning the reservoir's own suit, were paid by the reservoir company, and hence swells the account on this score.

As regards its own suit to compel the company to carry the water, an order to this effect was obtained from the county court of Weld County, which was, nearly as soon as given, countermanded by a judge of Arapahoe district court in the absence of the judge of this district; but upon hearing before this same judge, he reversed his own decision, and the farmers were allowed to carry their reservoir water in the canal of the company.

This was allowed partly on account of a statute of the State providing that a canal already in existence, and having the capacity and proper location to carry the water of a party not an owner of the canal, must carry it, and so prevent burdening the real estate with parallel canals, which were becoming a nuisance before the enactment of this law. In the present instance, if the farmers had been forced to build a canal to distribute their water, it must have been either immediately above or below a canal some 40 feet wide, and if above, they would have to flume across this canal wherever there was a lateral, the laterals being the property, in part at least, of the farmers who had lands under them. These laterals were as frequent as one a mile. On the other hand, if below, they would have to flume the reservoir's canal over each of these laterals, in fact, making a monstrosity of construction, a monument of human perversity and folly.

Of course, although the canal in an equitable sense belonged to each farmer in proportion to the quantity of water he had purchased to be delivered through it to his land, still legally the canal belonged to the canal company, and what the reservoir people got was a temporary easement for the use of the canal when there was but little or no water in the river to which the canal was entitled, and for this temporary use they were expected to pay. Another suit in court fixed the amount, which was made low by the jury, no doubt on account of the virtual part ownership of the farmers in the canal.

VIEW OF OUTLET AND EMBANKMENT OF LARIMER AND WELD RESERVOIR, FROM THE INSIDE, AFTER THE WATER IS DRAWN OFF.

They had paid, on an average, $1,000 apiece for each 80-acre water right, which was to be 1.44 cubic feet per second when there was water enough in the river. Taking out some 30 preferred rights granted the owners of the old ditch, there were in force some 340 of these rights, for which the company had received $340,000, while the construction of the canal had not cost more than $150,000. It was a part of the contracts with the farmers that they should become shareholders in the company as soon as the estimated capacity of the canal had been reached. But this question was in court, and, as we saw above, has been decided in favor of the farmers, namely, that it had been reached at the time they enjoined the company from further sales of water rights, because the deficiency of water in the river during the ordinary irrigation season prevented the company from being able to furnish. The ambiguous phrase "capacity to furnish" was at last, and by the highest court, construed against the company, which was the drawer of the instrument, in accordance with the general practice of the courts.

LAKE LEE.

At the time the order of the county court was issued to allow the reservoir people to take possession of the canal ıd run their water through to those entitled to receive it, there was running in the canal some 19 cubic feet of water per second belonging to its old appropriation. This was being stored in a reservoir named "Lake Lee," an expansion of the canal some 15 miles below its head. Its area is about 90 acres, and a depth of 9 feet can be drawn off when it is filled to the limit of height. When the water of the reservoir was turned into the canal, it mixed with that carried by the canal for the benefit of all consumers, while those owning and entitled to reservoir water were about one-half of the consumers. The order of the court therefore put the canal for certain-named days wholly in the hands of the reservoir people, under the penalty of damages to the other consumers. The writer was put in charge of the reservoir and canal at these times and until more amicable relations were restored. The plan adopted was to carefully measure the height of water in Lake Lee at the time the reservoir water reached it, and then to make an estimate as to the height to which the quantity in the canal would fill it during the days the reservoir water was being run. When the run was about finished, the outlet gates of Lake Lee were shut, so that there would be in it for all consumers what it was estimated would have been in it if the reservoir water had not been run. The instructions of the reservoir managers were to be sure and err on the side of leaving enough in Lake Lee, and the result was that no damages were claimed by the other consumers for loss of water by the operation of the canal by the reservoir company. Pl. XII shows the Larimer and Weld Canal at Lake Lee gates.

WINDSOR RESERVOIR.

It will be observed that this reservoir water was the property of about one-half of the consumers under the Larimer and Weld, and hence that only in the few cases where the others rented did they enjoy the use of the water. As a consequence, only those having reservoir water made a potato crop. Those outside of the reservoir, of whom the leader was B. H. Eaton, the owner of some 15,000 acres under the canal, undertook the construction of a reservoir for themselves. There is an excellent site for a reservoir some 25 miles from the head of the canal and close to it. The bottom of the canal at this point is about 50 feet above that of the reservoir. It has been filled to the depth of 28 feet and the water stored in it has been used for three years by means of the system of exchange before described. The cost of the reservoir up to date has been, as itemized by Mr. Eaton, as follows:

Land	$20,000
Condemnation and attorneys' fees	5,000
Outlet and inlet, the latter consisting mostly in enlarging the Larimer and Weld Canal from river to reservoir inlet	10,000
Surveying	1,000
Conduit and embankment	16,000
Total	52,000

The owners expect to expend $23,000 more to make it hold 12 feet more, or a depth of 40 feet of water at the conduit. This will be expended partly on the main canal, to enable it to take in flood water from the river for storage, and partly on the embankment. When the water is raised to the height of 40 feet, it is estimated the reservoir will hold 1,000,000,000 cubic feet.

The work on the embankment near the outlet conduit is in a very incomplete state, as will be seen from the accompanying view, Pl. XIII, taken from the inside of the reservoir when the water was drawn off. This shows the masonry in front and over the stone arch which forms the outlet. The gate, which is about 4 feet by 5 feet, is raised by a screw and lever. There is no flank masonry nor rock riprapping to protect the earth embankment. Such protective works were attempted by use of posts, poles, wire, and straw, but, as seen in the view, these were wrecked by the waves.

The conduit is of masonry laid in Portland cement; the bottom is of large, thick flagging stones procured in the foothills; the sides, 3 feet high and 4 apart, are crowned with an arch 2 feet high in the center; the walls of sides and arch, 2 feet thick, are of rubble masonry, resting upon the soft shale rock, which has between it and the flagging that forms the bottom some 6 inches of concrete made of gravel, sand, and Portland cement. There have been no signs of leakage along the surface of the conduit, but there is a tendency to

VIEW OF LOWER SIDE OF OUTLET OF THE LARIMER AND WELD RESERVOIR.

leak just above the shale into the outlet ditch below the end of the masonry of the conduit.

After the water has been raised in this and similar reservoirs the overlying clay becomes softened and sloughs off into the outlet canal. This was the occasion for great fear on the part of the people living under the Larimer and Weld Reservoir during 1895. A score or more of families abandoned their houses one rainy night when the reservoir was full and looked threatening. It is now proposed to wall up the outlet canals below the masonry conduits with a dry stone wall filled behind with gravel, which will allow the water to leak through while it prevents sloughing off.

When the Windsor Reservoir is complete it is planned to draw off the water at two levels, the one at the bottom, now in use, and another at a level 20 feet higher and distant 200 feet. The water from the upper outlet will be dropped into the same canal that is now used for the bottom level. The reason given for this is ease of management of the gates, which would be hard to raise under a pressure of 40 feet.

LARIMER COUNTY CANAL.

Larimer County Canal is to the north of and in general parallel with the Larimer and Weld Canal, covering a strip of land above the latter. It heads on Cache la Poudre Creek, about 8 miles higher up, but for its water supply this canal has for the most part been dependent upon a system of reservoirs, since it is the latest of those of large size in the valley, being preceded by 99 claims, aggregating 4,082.65 second-feet. In order of priority it follows third after the North Poudre Canal and Reservoir Company, there being two claims of 157.40 feet between. By its head in the main river, however, it obtains late water whenever, at rare intervals, there is any.

This canal was built by residents of the valley, who, though having the evidence of a deficiency of water before them, yet hoped that the unusually large supply of previous years would prevail in the future. They overestimated not only the supply obtainable for storage in reservoirs, but also the land that could be sufficiently irrigated from a given amount of water. Hence it may be said that until the last two years farming under this canal has been a series of failures. This company has on the plains six reservoirs fed by the canal. Of these two are important, Long Pond and Rocky Ridge. These have a united capacity of 340,000,000 cubic feet, or 7,500 acre-feet. The total storage capacity of all its reservoirs claimed is 480,000,000 cubic feet, or 10,560 acre-feet.

CHAMBERS LAKE RESERVOIR.

A company known as the Larimer County Reservoir Company placed a dam in the outlet of Chambers Lake, a natural storage basin near the head waters of the Middle Fork of Cache la Poudre Creek. The

irrigators interested in the waters of this stream, fearing a scarcity of supply, commenced suit on the ground that the statute gave only the right to take water from a stream and store it, and not to place a storage dam in the stream itself. The dam, however, was constructed, but on June 9, 1891, it broke, letting the contents of the reservoir sweep down the channel of the river and inflicting much damage upon the farms situated in the narrow mountain valley. Passing through the canyon below the valley, it overspread the lower bottom lands, carrying away bridges, the force gradually diminishing as the mouth of the river was reached.

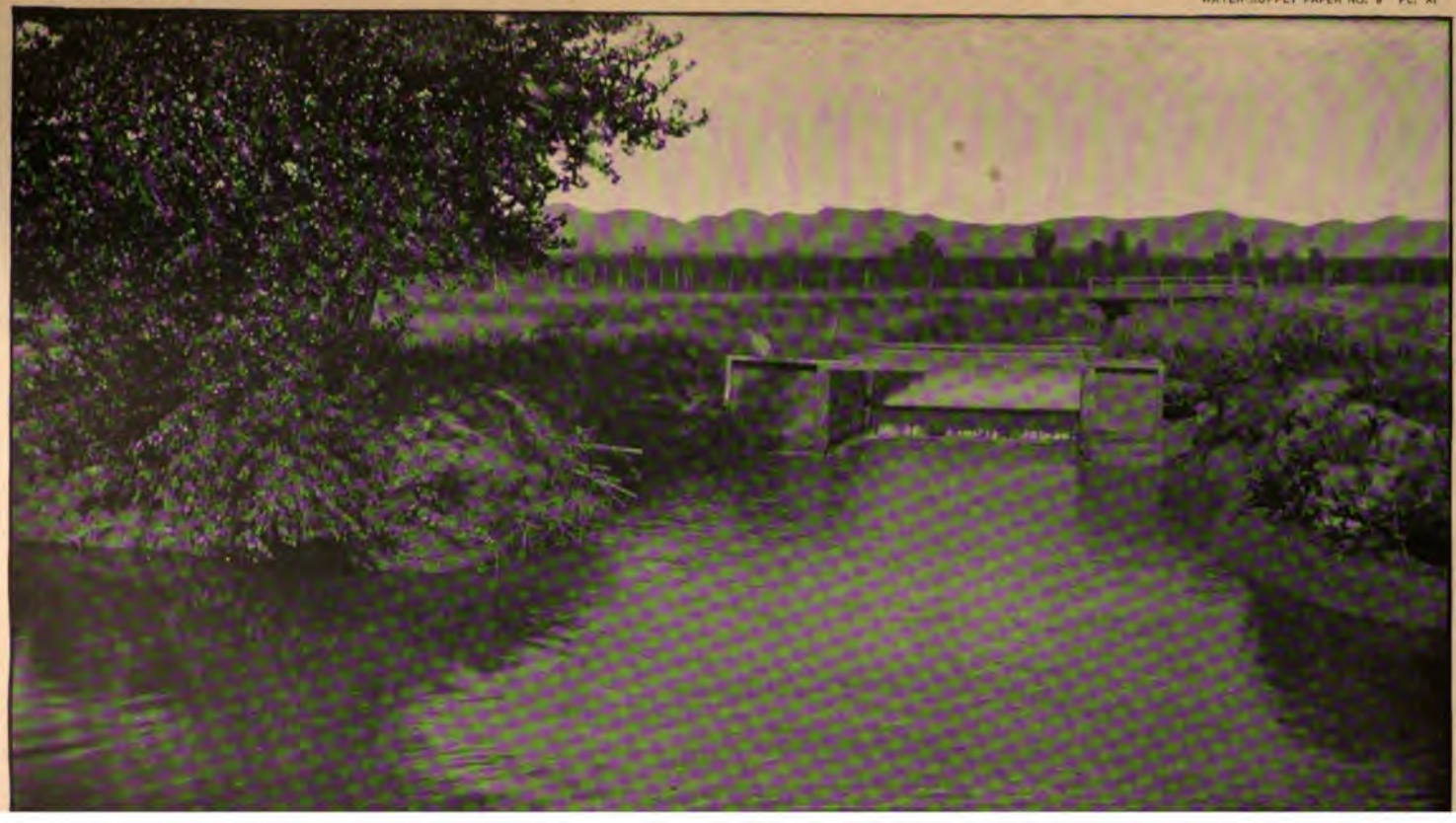
The parties injured sued and recovered damages, and as the reservoir company had no property but the destroyed dam, suits were brought against the Larimer Canal Company, on the ground that since it had been renting the water and was the controlling factor of the reservoir company it should be held responsible. It was held that any one placing a dam in a natural stream was responsible for injury resulting from its destruction.

The irrigators of the valley as a rule were not displeased to have this dam destroyed, as it was generally believed that water was unjustly taken from the river. The dam being 70 miles above the gaging station, out of the reach of the river commissioner, and wholly in charge of employees of the canal company, it was impossible to verify this belief. The experience gained here justifies the statement that no structure of this kind should be built except under State supervision or in accordance with regulations prescribed by the State engineer, such as will insure absolute safety in the building and management of dams, especially those upon the main drainage lines.

SKY LINE DITCH.

In 1892 the company owning the Larimer County canal was reorganized under the name "Water Supply and Storage Company," and during the next year undertook the work of building a ditch above Chambers Lake for the purpose of diverting into Cache la Poudre Valley water from the upper feeders of the Laramie River, a tributary of the North Platte. This ditch, shown in Pls. I and XIV, bears the graphic name of the "Sky Line," as it is about 10,000 feet in altitude. It is 5 miles long, has a capacity of about 100 second-feet, and cost $90,000. The work was practically all in rock, with but little fluming. In places it was necessary to build a bench of timber to support the lower bank, which is mostly of rock.

The Sky Line ditch takes water from streams so high up that it receives no supply until about the middle of June. The river commissioner estimates the amount delivered in 1895 at 650,000,000 cubic feet, or 14,300 acre-feet. During the season when water is being run the company keeps three men on this short canal to maintain it and to regulate the flow at the head so as to get as much water as possible.



As it is 70 miles above the gaging station, the river commissioner can not visit this canal to ascertain how much it is furnishing the river, and must depend upon the reports made by mail three times a week by the party in charge. When it has a full supply it furnishes about 100 feet, but later, by the 1st of September, it sinks to 25 feet. During 1894 and 1895 the water from the Sky Line ditch and that stored in the reservoirs has been practically all the supply the Larimer County Canal has had, and fair crops have been made. The capacity of the canal on the plains is said to be 469 feet, but it is apparent that it has only a sure supply of 100 feet besides the reservoirs, the contents of which are now used before the water from the Sky Line is available.

Since the reservoirs belonging to this canal are filled from it, the water, being at a lower elevation, can not run back and be distributed by means of it. Hence other distributing canals would need to be built and could supply water only to the lower lands. Instead of this, a system of exchange with the river has been adopted through the consent of all parties and in accordance with a ruling by the State engineer. This may be effected either by dropping the water of the reservoirs back into the river for the use of canals below, which are all older, or it may be accomplished by running the reservoir water directly into either the Larimer and Weld or the Cache la Poudre Canal when either is entitled to water. An equal amount is then claimed from the river. Not only do the reservoirs of this canal make this exchange, but also those filled from the Larimer and Weld Canal next below. This receives the river water of the Cache la Poudre Canal, which is just below and also older. This exchange has worked well and is a great saving of expense in construction of distributing canals. It also renders the water available for all the lands that the canal can reach.

The reservoirs of the Larimer County Canal Company have not been very expensive to construct, as but little or no embankments have been made. The conduits from the two principal ones are made of rock, the bottom and cover of large, thick flagstones, with joints filled with cement mortar, and the sides are of rubble masonry laid in cement. The largest two can be filled to 30 feet, and the gates are raised by a screw. Each cost for construction about $10,000 and $2,000 for right of site.

APPROPRIATIONS FROM CACHE LA POUDRE CREEK.

In addition to the three canal systems described above there are in all about 25 other canals and ditches taking water from Cache la Poudre Creek, most of these being relatively small. Without describing these it will be recognized that the apportionment of water among all these canals and ditches must be a matter of extreme difficulty. It is further complicated by the fact that many of these have more than one appropriation, so that although a list of the ditches as given

on pages 51–52 shows only 28, there have been up to 1888 as many as 104 separate appropriations of water from Cache la Poudre Creek and its tributaries, these being due to the amount of water claimed at the original construction and by the several enlargements, especially of the older ditches. The matter is fully set forth in the following table taken from the State Engineer's Report for 1888:[1]

Appropriations from Cache la Poudre Creek.

Order of priority in district.	Name of ditch, canal, or reservoir.	Date of appropriation.	Cubic feet of water per second decreed to each priority.	Summation of decree to each ditch, canal, or reservoir.	Cubic feet of water previously appropriated in district.
1	Yeager	June 1, 1860	24.80		
2	Watrous, Whedbee & Secord	June 1, 1861	1.44		24.80
3	Dry Creek	June 10, 1861	11.67		26.24
4	Pleasant Valley and Lake	Sept. 1, 1861	10.97		37.91
5	Pioneer	Mar. 1, 1862	12.92		48.88
6	Boyd & Freeman	Mar. 15, 1862	66.05		61.80
7	Whitney	Sept. 1, 1862	48.23		127.85
8	Yeager (upper branch), first enlargement	June 1, 1863	8.70	33.50	176.08
9	B. H. Eaton	Apr. 1, 1864	29.10		184.78
10	Larimer and Weld	June 1, 1864	3.00		213.88
11	Pleasant Valley and Lake, first enlargement	June 10, 1864	29.63	40.60	216.88
12	Pioneer, first enlargement	Sept. 15, 1864	16.67	29.59	246.51
13	John G. Coy	Apr. 10, 1865	31.63		263.18
14	John R. Brown	May 1, 1865	8.00		294.81
15	Box Elder	Mar. 1, 1866	32.50		302.81
16	Chamberlin	Apr. 1, 1866	14.83		335.31
17	Taylor & Gill	Apr. 15, 1866	18.48		350.14
18	B. H. Eaton, first enl	June 1, 1866	3.33	32.43	368.62
19	Watrous, Whedbee & Secord, first enlargement	July 1, 1866	4.33	5.77	371.95
20	Boyd & Freeman, first enl	July 15, 1866	9.00	75.05	376.28
21	Larimer and Weld, first enl	Apr. 1, 1867	16.67	19.67	385.28
22	Mason & Hottell mill race	Apr. 15, 1867	93.07		401.95
23	Box Elder, first enl	May 25, 1867	8.33	40.83	495.02
24	Wm. R. Jones	Sept. 1, 1867	15.52		503.35
25	Josh Ames	Oct. 1, 1867	35.92		518.87
26	Martin Calloway *a*	Mar. 1, 1868	15.22		554.79

[1] Fourth Biennial Report of the State Engineer of Colorado for the years 1887 and 1888, pp. 148, 149, 150.

a Takes water from Boxelder Creek.

VIEW OF LARIMER AND WELD CANAL AT THE LAKE LEE GATES.

Appropriations from Cache la Poudre Creek—Continued.

Order of priority in district.	Name of ditch, canal, or reservoir.	Date of appropriation.	Cubic feet of water per second decreed to each priority.	Summation of decree to each ditch, canal, or reservoir.	Cubic feet of water previously appropriated in district.
27	Noah and Philo Bristol (lower) *a*	Mar. 10, 1868	15.22	.....	570.01
28	Cañon Canal Co	Mar. 15, 1868	8.60	.....	585.23
29	Watrous, Whedbee & Secord, second enl	June 1, 1868	4.33	10.10	593.83
30	Box Elder, second enl	July 1, 1868	11.93	52.76	598.16
31	Irrigating Ditch Co	May 1, 1869	60.08	.....	610.09
32	Fort Collins	June 1, 1869	1.67	.....	672.17
33	New Mercer Ditch Co	Sept. 1, 1869	4.17	.....	673.84
34	Noah and Philo Bristol (upper) *a*	Mar. 1, 1870	14.83	.....	678.01
35	Canal No. 3, Union Colony	Apr. 1, 1870	52.00	.....	692.84
36	Dry Creek, first enl	Oct. 21, 1870	14.42	26.09	744.84
37	Cache la Poudre Co	Oct. 25, 1870	110.00	.....	759.26
38	Fort Collins Irrigating, first enlargement	Apr. 1, 1871	31.66	33.33	869.26
39	Burnham & Emerson *b*	do	26	.....	900.92
40	Wm. Calloway No. 1 *c*	May 1, 1871	21.05	.....	926.92
41	Mill Power	July 1, 1871	160	.....	947.97
42	Fletcher	Sept. 1, 1871	63.16	.....	1,107.97
43	Whitney, first enl	Sept. 10. 1871	12.95	61.18	1,171.13
44	Cache la Poudre Co., first enlargement	Sept. 15, 1871	170	280	1,184.08
45	Larimer and Weld, second enlargement	Sept. 20, 1871	75	94.67	1,354.08
46	Canal No. 3, first enl	Oct. 1, 1871	41	93	1,429.08
47	New Mercer Ditch Co., first enlargement	Oct. 10, 1871	8.33	12.50	1,470.08
48	Chaffee Irrigating	Mar. 15, 1872	22.38	.....	1,478.41
49	New Mercer Ditch Co., second enlargement	July 1, 1872	15	27.50	1,500.79
50	Canal No. 3, second enl	July 15, 1872	63.13	156.13	1,515.79
51	Pleasant Valley and Lake, second enlargement	July 19, 1872	16.50	57.10	1,578.92
52	Fort Collins Irrigating, second enlargement	July 20, 1872	33.33	66.66	1,595.42
53	B. H. Eaton, second enl	July 25, 1872	9.26	41.69	1,628.75

a Takes water from Boxelder Creek.
b Takes water from Lone Pine Creek.
c Takes water from north fork of Cache la Poudre Creek.

Appropriations from Cache la Poudre Creek—Continued.

Order of priority in district.	Name of ditch, canal, or reservoir.	Date of appropriation.	Cubic feet of water per second decreed to each priority.	Summation of decree to each ditch, canal, or reservoir.	Cubic feet of water previously appropriated in district.
54	Lake Canal	Nov. 1, 1872	158.35		1,638.01
55	Wm. S. Taylor	Mar. 15, 1873	28.60		1,796.36
56	Cañon Canal Co., first enl	Mar. 20, 1873	48.88	57.48	1,824.96
57	Larimer County Canal, No. 2	Apr. 1, 1873	175		1,873.84
58	Irrigating Ditch, first enl	May 1, 1873	20.42	82.50	2,048.84
59	Canal No. 3, third enl	May 15, 1873	16.65	172.80	2,069.26
60	Aquilla Morgan *a*	July 1, 1873	17.65		2,085.91
61	Brown No. 1 *b*	do	9.38		2,103.56
62	Boyd & Freeman, second enlargement	Aug. 1, 1873	24.23	99.28	2,112.94
63	Brown No. 2 *b*	Aug. 15, 1873	3.32		2,137.17
64	Strudevant No. 1 *c*	do	10.66		2,140.49
65	Strudevant No. 2 *c*	Aug. 20, 1873	10.66		2,151.15
66	Fort Collins Irrigating Ditch, third enl	Sept. 1, 1873	63.28	129.94	2,161.81
67	Dry Creek, second enl	Sept. 15, 1873	12.13	38.22	2,225.09
68	Vandewark	May 1, 1874	10.17		2,237.22
69	Brown No. 3 *b*	May 15, 1874	3.32		2,247,39
70	Mitchell & Weymouth No. 1 *d*	do	17.35		2,250.71
71	Andrew Boyd et al. *b*	Nov. 1, 1874	15.03		2,268.06
72	Cache la Poudre Co. Canal, second enlargement	Nov. 10, 1874	184	464	2,283.09
73	Larimer & Weld, third enlargement	Jan. 15, 1875	54.33	149	2,467.09
74	Wm. Calloway No. 2 *a*	Jan. 28, 1875	14.16		2,521.42
75	Witzler et al. *d*	Mar. 22, 1875	10.36		2,535.58
76	Warren Lake Reservoir (see. 56)	Apr. 15, 1875			
77	Brown, No. 4 *a*	May 1, 1875	6.72		2,545.94
78	Kitchel & Ladd	Oct. 1, 1875	2.95		2,552.66
79	Brown, No. 5 *a*	June 1, 1876	6.72		2,555.61
80	Brown, No. 6 *a*	do	6.72		2,562.33
81	Witzler et al., first enl. *d*	Mar. 1, 1877	3	13.36	2,569.05
82	Brown, No. 7 *a*	June 1, 1877	2.85		2,572.05

a Takes water from north fork of Cache la Poudre Creek.
b Takes water from Fish Creek.
c Takes water from Boxelder Creek.
d Takes water fro mLone Pine Creek.

VIEW OF OUTLET OF WINDSOR RESERVOIR FROM THE INSIDE.

Appropriations from Cache la Poudre Creek—Continued.

Order of priority in district.	Name of ditch, canal, or reservoir.	Date of appropriation.	Cubic feet of water per second decreed to each priority.	Summation of decree to each ditch, canal, or reservoir.	Cubic feet of water previously appropriated in district.
83	Cache la Poudre Co.'s, third enlargement	Sept. 15, 1877	121	585	2,574.90
84	Henry Smith	Apr. 1, 1878	7.23		2,695.90
85	Abram Washburn, No. 1	Apr. 15, 1878	9.57		2,703.13
86	Roberts, No. 1 *a*	do	5.76		2,712.70
87	Boxelder Reservoir Co. *b*	June 18, 1878	17.50		2,718.37
88	Larimer and Weld, fourth enlargement	Sept. —, 1878	571	720	2,735.87
89	Carter Cotton mill race	Apr. 1, 1879	127.30		3,306.87
90	Abram Washburn, No. 2	Apr. 15, 1879	15.43		3,434.17
91	Dry Creek, third enl	July 15, 1879	12.70	50.92	3,449.60
92	Pleasant Valley and Lake, third enlargement	Aug. 18, 1879	80.83	137.93	3,462.30
93	John McKay et al. *a*	Sept. 1, 1879	3.40		3,543.13
94	Fisk, No. 2 *a*	Dec. 1, 1879	10.28		3,546.53
95	Carter Cotton mill race, first enlargement	Dec. 31, 1879	37.17	164.47	3,556.81
96	Mitchell & Weymouth, No. 2 *c*	Jan. 19, 1880	16.27		3,593.98
97	North Poudre Land, Canal and Res. Co. *a*	Feb. 1, 1880	315		3,610.25
98	New Mercer Ditch Co., third enlargement	Feb. 15, 1880	136	163.50	3,925.25
99	Chase *a*	July 7, 1880	21.40		4,061.25
100	Larimer County	Apr. 25, 1881	469.80		4,082.65
101	Eagle Ranch *a*	Oct. 1, 1881	5.02		4,552.45
102	Pleasant Valley and Lake, fourth enlargement	Oct. 10, 1881			
103	Emerson Bros. *c*	Apr. 15, 1882	29.88		4,602.65
104	Roberts, No. 1, first enl *a*	Sept. 1, 1882	*d*4.09		4,632.53

a Takes water from north fork of Cache la Poudre Creek.
b Takes water from Boxelder Creek.
c Takes water from Lone Pine Creek.
d Up to 1897 only two changes have been made in this table. The first is in the reduction of No. 1, Yeager Ditch, from 24.80 cubic feet per second to 3 cubic feet per second. The second is a change in the order of priorities, by which No. 100, Larimer County Canal, becomes 97 and old 97, 98, and 99, become, respectively, 98, 99, and 100.

The above table is worthy of especial notice, since it is the guide for the district water commissioner in his distribution of water. When an earlier appropriator of water has less at his head gate than

he needs, and when he believes that some later appropriator farther up the stream is getting water to which he deems himself entitled, he notifies the water commissioner, usually by telephone, of the situation, and if the commissioner deems his complaint well grounded, No. 104 is shut off, then 103, and so on up the list until the deficiency is remedied.

It will be seen that some of the canals have several enlargements, each of which stands upon its date of construction, as decreed by the district court. Cache la Poudre Company's Canal—original name, No. 2, of Union Colony—is an example. The original construction, No. 37, dates back to October 25, 1870. It is credited with a capacity of 110 second-feet, but there were 36 claims on the river preceding it, demanding in the aggregate 759.26 second-feet. The first enlargement, No. 44, dates from September 15, 1871, and is credited with 170 second-feet, which at that date made its total capacity 280 second-feet. At that time 43 claims preceded it, with an allowance of 1,184.08 second-feet. The second enlargement, No. 72, dates from November 10, 1874, and is credited with 184 second-feet, making in all 464 second-feet. This enlargement is preceded by claims for 2,283.09 second-feet. The third enlargement, No. 83, dates from September 15, 1877, and calls for 121 second-feet, making in all 585 second-feet, being preceded by claims for 2,574.90 second-feet.

The capacity of the river is such that if all these claims were valid there would be scarcely enough water to allow this canal its last appropriation, much less the Larimer and Weld for its fourth enlargement, No. 88, or 571 second-feet, its principal appropriation, but which is preceded by claims for 2,735.87 second-feet, which exceeds even the average June supply for every year on record excepting 1883, 1884, and 1885.

The third irrigating system in point of size is the Larimer County Canal. It is appropriation No. 100, and the canals preceding it call for 4,082.65 second-feet, a volume to which the river rarely ever rises, and which has been exceeded only in June 1883 and 1884.

To illustrate how excessive is the rating of these older ditches, take the Boyd and Freeman Ditch. It stands No. 6 on its original construction, and is granted 66.05 second-feet, dating March 15, 1862, or eight years before the settlement of Union Colony at Greeley. By reference to the table it may be seen that this ditch claims only 900 acres under it, mostly grass. This would give a duty of only 13.7 acres per cubic foot per second, even if it claimed only its first appropriation. In addition to this, however, it has two enlargements, bringing its claims up to 99.28 second-feet, or a duty of only 9 acres per second-foot. This matter is further discussed at length in the reports of the State engineer, notably in the Sixth Biennial Report, for 1891 and 1892, pages 13 to 17.

ANOTHER VIEW OF SKY LINE CANAL.

EXTRAVAGANT CLAIMS TO WATER.

This excessive adjudication was obtained largely by false testimony or was due to the ignorance of the witnesses, not even those who pretended to be engineers being able to compute the probable capacity of a canal from its slope and sectional area. Where formulas were used they were not applicable to small, crooked, poorly constructed ditches, such as were the early ones. Had there been water running in the river at the time the referee of the court took the testimony, the actual size of the ditches could have been approximated somewhat more closely; but it was late in the autumn of 1879 when this was being done, and the river was very low at the time. Moreover, there was no attempt made by the referee to have the ditches measured. This could have been done in the case of the smaller ones, which were also the ones whose capacity were the most excessively estimated. How much the capacity of the canals exceeds the supply can be seen by comparing the above decreed allowance with the table of estimated mean monthly flow given on page 27.

CACHE LA POUDRE CREEK.

When, in 1870, the Union Colony settled in the lower end of the valley and founded the town of Greeley, there were only about 1,000 acres in cultivation, all upon the bottom lands near the river, but the small canals then constructed claimed and had awarded them as appropriated 692.84 second-feet. There were in all some 23 small ditches taken out of Cache la Poudre Creek before 1870. If from this number are taken 4 small canals that were afterwards enlarged and at this time claimed only 42 second-feet, it is found that the 19 remaining ditches had under them in crops, according to the report of the State engineer for 1888, only 5,660 acres. To water this area they had at this latter date claims awarded them to the amount of 650 second-feet, or a cubic foot for every 10 acres. However, a provision in each decree restrains each ditch to so much of the quantity awarded as is needed for beneficial use and prohibits all waste. There are only 9 canals shown in the State engineer's report for 1894 that have records of the water taken in at their head gates for that year. These had crops to the extent of 106,000 acres, while the remaining 19 had only about 10,000 acres under crops. The fact is that by means of the irrigation of the uplands under the later larger canals, the lands under these lower canals, for the most part, need no water, but are, on the contrary, in many instances transformed into swamps.

There has been an opinion prevalent among the owners of the bottom-land canals that they, in some way, owned the water awarded by the court to their ditches which they could sell to other ditches when they did not need to use it where originally located. Moreover, if they did not need all of the water, or if, in fact, their ditches

could not carry it, the owners thought that they had a right to sell or transfer the remainder to such persons or places as they might find convenient. While there might be some justice in allowing a person whose land was ruined by the irrigation of the uplands a right to use as much water as he had actually used upon these lands through some other canal; it would have been ruinous to later canals to allow a transfer of the excessive quantities erroneously decreed to the earlier. This situation is now well understood, and later decrees by the courts in other districts base grants to water to a canal only to the extent that it is proved that the water has been applied. These excessive claims allowed by the courts affect every district in the division of the Platte, and are even more extravagant in others than in Cache la Poudre district; so the people of Greeley engaged an attorney to cross-question witnesses and restrict claims as much as possible.

CONSERVATION OF WATER SUPPLY.

From a consideration of the appropriations of water from Cache la Poudre and a comparison of these with the amount actually flowing at the upper end of the valley, it is evident that there must be a deficiency in ordinary years. In years of scarcity the lands under all but the oldest canals do not have sufficient water to enable them to make a full crop. This is demonstrated by the fact that in 1894 the crops under all the later canals were more than double those of the averages of the preceding five years, these being periods of less than average flow. Even in 1894 the lands under the older canals, having all the water needed, produced better than those more stinted. This is shown by a comparison of the lands under the three largest canals of the valley. These are shown in the following table in the order of priority of appropriations:

Name.	Total area in crop.	Quantity of water.	Depth.
	Acres.	*Acre-feet.*	*Feet.*
Cache la Poudre Irrigation Company's canal	22,045	70,610	3.2
Larimer and Weld Canal	44,384	77,225	1.7
Larimer County Ditch	16,714	27,830	1.66

It is shown that the acreage under the first is about half that under the second, and, as can be seen from the table on page 52, there was half as much wheat, about as much oats, more than half as much barley and corn, and more potatoes. The latter is the most important crop, one-fourth of the land cultivated under each of these two canals being in potatoes. The showing under the Larimer County Ditch was still worse, as it had more than two-thirds as much land as the first

under crops, while it had less than two-thirds as much wheat, less than one-third as much oats, a trifle more than its ratio of barley, but less than one-fifth as many potatoes.

These three canals, it will be seen, have under them about two-thirds of all the land in the valley. The rated capacities of these canals, for which the court has issued decrees, are 580, 720, and 480, the sum being 1,780 cubic feet per second. The total claimed by canals in this district at the end of 1888 and for which decrees had been granted them by the court, as shown on page 47, was 4,632.53 second-feet; that is, three canals have set apart to them by appropriation, as the decrees of the court stand, only about 38.4 per cent of the flow of the stream, while they have 66.6 per cent of the land irrigated. Many of the smaller ditches never could carry the quantities which were granted them by decree of the district court, and if they could carry them, they could not possibly use them.

CROP AREA.

The following table gives the crop statistics of Cache la Poudre Valley as obtained from a house-to-house canvass of the entire district.[1] Although absolute accuracy is not attainable in such matters, it is more nearly complete than anything of the kind that has been heretofore attempted in this State. There is also appended in the right-hand column a statement of the water received in 1894 by the nine principal canals, these being the only ones concerning whose intake a record was kept by the district commissioner:

Crop statistics in district No. 3—1894.

Name of canal or ditch.	Total.	Alfalfa.	Other grass.	Other crops.	Pasture and waste.	Wheat.	Oats.	Barley.	Corn.	Potatoes.	Fruit.	Water used.
	Acres.	*Acres*	*Acres*	*Acres*	*Acres*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Sacks.*	*Acres*	*Acreft.*
North Poudre	11,149	843	795	2,430	7,081	41,731	20,102	1,793	3,775	5,687	3	18,306
Larimer County	27,844	4,010	.....	12,847	11,131	89,774	23,855	7,209	4,075	113,795	35¼	27,803
Larimer and Weld	59,507	7,428	878	32,182	15,123	283,998	89,004	17,599	6,702	554,303	53¼	77,225
Pleasant Valley and Lake	8,221	1,750	470	2,234	3,110	7,338	11,578	830	1,972	3,655	123	17,387
New Mercer	4,256	1,664	174	1,020	1,867	17,999	21,941	8,075	2,032	13,448	101¼	11,110
Larimer County, No. 2	8,623	2,751	61	2,680	985	34,881	14,190	7,120	280	10,389	70¼	18,545
Fort Collins	1,179	492	45	387	374	720	799	425	65	860	33	.....
Dry Creek	3,160	1,131	223	453	991	1,989	3,257	.....	.....	350	41¼	7,984
Little Cache la Poudre	1,300	567	61	642	204	1,544	2,033	.....	.....	1,420	24¼	.....
Taylor & Gill	464	159	9	174	164	.....	300	175	100	1,350	28¼	.....
John R. Brown	290	60	75	70	85	.....	490	.....	.....	.....	5	.....
From seepage	.....	62	115	433	450	2,700	6,245	2,435	1,530	8,050	4	.....
Cañon	497	160	5	90	197	250	120	57	300	500	5	.....

[1] Seventh Biennial Report of the State Engineer of Colorado, for the years 1893 and 1894, p. 22.

Crop statistics in district No. 3—1894—Continued.

Name of canal or ditch.	Total.	Alfalfa.	Other grass.	Other crops.	Pasture and waste.	Wheat.	Oats.	Barley.	Corn.	Potatoes.	Fruit.	Water used.
	Acres.	*Acres*	*Acres*	*Acres*	*Acres*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Sacks.*	*Acres*	*Acre ft.*
Watrous, Wheedbe & Secord	120	20	.....	25	75	.....	.....	.....	.....	600	.....	.....
Box Elder and Res. Co.'s	1,280	50	.....	100	1,000	900	300	.....	25	200	.....	.....
Josh Ames	460	24	50	110	276	1,600	516	1,100	150	1,400	.....	.....
City	28	3	.....	3	20	.....	.....	.....	.....	.....	.....	.....
Lake	6,242	1,007	156	1,762	2,076	19,900	15,516	1,282	3,855	23,280	10¼	11,262
John G. Coy	300	60	80	45	115	260	240	.....	75	620	.....	.....
Pioneer	682	280	50	55	442	240	1,700	.....	.....	1,000	2	.....
Box Elder	1,735	270	144	351	1,028	1,077	1,467	634	95	3,184	.....	.....
Cache la Poudre Irr. Co.'s	33,173	5,032	704	15,065	11,128	144,224	82,628	9,837	3,670	602,485	42¼	70,610
Whitney	2,080	358	55	652	683	4,410	6,051	.....	100	17,500	3¼	.....
B. H. Eaton	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Cache la Poudre Irr. Co.'s, No. 3	1,275	147	103	517	480	1,875	1,140	.....	.....	14,652	.....	.....
Wm. R. Jones	360	75	119	135	149	300	1,600	.....	250	2,240	1	.....
Boyd & Freeman	900	90	350	300	158	.....	1,575	1,575	300	7,000	2	.....
Ogilvy	3,800	720	.....	1,357	1,728	13,290	7,465	.....	.....	29,660	.....	.....
Total	178,923	29,193	4,722	76,119	61,120	671,000	314,112	60,146	29,351	1,417,628	591¼	260,232

From the above table it will be noted that there are 61,120 acres recorded as waste and pasture land. Parts of this, perhaps not more than 2,000 acres, are above the levels of the canals, but the larger proportion is near the river and is kept so wet by the irrigation of the uplands that it needs no further application of water. Much of it has changed into cat-tail and rush-bearing swamps. This is true of certain basins and valleys among the uplands. Some of these basins have been utilized as reservoir sites. These are chiefly found in the upper end of the valley, on the north side. The surface of the country here is quite rolling. The soil is a somewhat stiff clay, resting upon a soft argillaceous shale which rises to near the brim of these basins, and thus renders them nearly water-tight.

Nearly all the land under cultivation, that is, under canals, is on the north side of the river, the only exception being a small area of about 12,000 acres near Fort Collins. The reason is that below the point where the canals on the south side are seen to terminate the level of the land rises abruptly from the first bottom of the river to a height of from 50 to 100 feet. Near Greeley the bluffs lower and enable a small area in and near the town to be brought under a canal taken from Cache la Poudre Creek about 6 miles above the place. The hilly region to the south and west of Greeley is irrigated by the Loveland and Greeley Canal, which takes its water from Big Thompson Creek, the next tributary of the Platte above Cache la Poudre Creek.

AMOUNT OF WATER USED.

The mountain watershed of Cache la Poudre Creek above the gaging station is about 1,060 square miles, or 678,400 acres. The area actually irrigated by the water which passes this point was computed by Prof. L. G. Carpenter to be 135,000 acres,[1] this being less than one-fourth of the extent of the mountain gathering ground. The total discharge as measured by the intake of the canals in 1894 during the irrigating season is computed by Professor Carpenter at 284,000 acre-feet. This would give a depth of run-off for that period of about four-tenths of a foot for the mountain watershed. This was a year of far more than average flow. It has been stated that the average for the four years ending 1892 was 227,302 acre-feet, which would give a depth of yearly run-off of about one-third of a foot.

The average discharge of all of the tributaries of South Platte River for the five winter months—November to March, inclusive—for four years, as given by the reports of the State engineer, was 472 second-feet, or 141,364 acre-feet. As irrigation is carried on during the other seven months, this amount is all that was available for storage except during times of flood.

The discharge of Cache la Poudre Creek for the five winter months was, from an average of these four years, 24,858 acre-feet, a quantity much exceeded by the capacity of reservoirs now constructed. The total average flow of the tributaries of Platte River for the other seven months is approximately 1,900 cubic feet per second, which for 213 days would be 34,966,000,000 cubic feet, or 769,252 acre-feet. The average for Cache la Poudre Creek for same months of the four years is about 500 cubic feet per second, or 9,202,000,000 cubic feet, or 202,444 acre-feet.

The area irrigated in 1892, as given in the engineer's report for the Platte division, was 678,620 acres, while in Cache la Poudre district it was 162,239 acres for the same year. This would give a depth of 1.13 feet over the area of the division of the Platte and of 1.24 feet for the Cache la Poudre district from the water received through the canyons of the respective streams. To this must be added the amount received from return seepage, or "underflow," which is used within the Platte division. The greater portion of the return from irrigation of Cache la Poudre district is also used within that district. As nearly as can be estimated, the return at that time was, for the whole division, about 1,000 second-feet, while that used in Cache la Poudre district is about 100 second-feet. This, added to the depths, respectively, would give for the division a depth of 1.70 feet of water applied, and for the Cache la Poudre district 1.49 feet.

The water flow during the four years under consideration, namely, 1889–1892, was below the average. The amount of water taken into

[1] Colorado Experiment Station Bulletin No. 22, January, 1893, p. 24.

all the canals during the irrigation season of 1894 in Cache la Poudre district, as measured by the commissioner of the district, was 260,232 acre-feet. If the same number of acres are considered as irrigated as in the other period, these results for 1894 give a depth of 1.70 feet. If, however, the area stated to be under crops in the report of the commissioner is taken, including in this meadows and alfalfa fields and rejecting that included under the heading "Waste and pasture lands," which are scarcely at all irrigated, it is found that the water received by the canals would have covered the land to the depth of 2.45 feet. This leaves out of account the waste by evaporation and percolation from some 332 miles of main canals and several times that length of laterals, which would be not less than 20 per cent. This amount, subtracted from the above, gives a depth of 1.96 feet.

QUANTITY AVAILABLE FOR STORAGE.

It has been found that the average flow through the canyon for the five months from November to March is about 84 second-feet. If to this is added the return underflow between the gaging station at the canyon and the head of the canal that feeds Cache la Poudre reservoir, there will be had the total winter water available for storage.

The shrinkage in return underflow during the winter, when the lands draining into the Poudre are not being irrigated, is greater in the upper end of the valley, between Fort Collins and the gaging station, than between Fort Collins and the mouth of Cache la Poudre Creek on account of the narrowness of the upper irrigated belt compared with the lower. In other words, the return underflow will be more constant in proportion to the width of the belt irrigated, since lands adjacent to the stream soon drain back into it all their surplus water when the source of this is cut off.

The average gain from the canyon down to Fort Collins, as shown by the two autumn seepage measurements of 1893 and 1894, was 28 second-feet, and by that of March, 1894, was 5 second-feet. The mean of these gives a little over 16 second-feet, which can be added to the winter flow through the canyon of 84 second-feet.[1] This gives an average total for storage purposes of 100 feet. All the underflow below this, out of the irrigation season, goes into the Platte and is not now stored, nor can it be stored for use on the lands of Cache la Poudre Valley. Suitable basins are found below on the north side of the Platte, in which can be stored the winter waste of the Platte and all its tributaries. These basins have been surveyed and articles of incorporation filed for their construction, but the enterprise is supposed to involve the expenditure of a million and a half dollars, and the capital to push it through is not yet forthcoming.

[1] Colorado Agricultural Experimental Station Bulletin No. 33. Seepage or return waters from irrigation, by L. G. Carpenter, pp. 20-22. Jan., 1896.

The total average winter supply of Cache la Poudre Creek for storage in reservoirs, all of which are now adjuncts of the four largest canals, may therefore be set down at 100 feet per second for 150 days, 1,296,000,000 cubic feet, or 29,750 acre-feet. Those under the North Fork canal do not come under this estimation, as the water they have been storing comes from that tributary above the gaging station.

The reservoirs of the Larimer County Canal claim 458,000,000 cubic feet, the two largest ones of the Larimer and Weld 900,000,000, and the Cache la Poudre Reservoir claims 368,000,000, making in all 1,726,000,000 cubic feet, and if this be reduced 30 per cent for overestimation, we have a corrected capacity of 1,208,000,000 cubic feet, or 88,000,000 cubic feet less than the average available winter supply. But this does not take into account evaporation and percolation that are taking place the year round from the reservoirs. The five main reservoirs have an average water surface for the year of about 1,200 acres, the minimum being about 300 acres and the maximum 2,100. The evaporation from a water surface in this climate is found to be about 6 feet deep. This would give a loss from the surface of the reservoirs of 7,200 acre-feet, or 313,000,000 cubic feet.

The extent of percolation can be estimated with much less certainty; but from the character of the sites of all the storage basins, save that of the Cache la Poudre Reservoir, it can not be great, since they are underlain by an impervious shale rock which also rises to form their rims. A tenacious clay overlies this rock, and hence it would appear that percolation would be small except through the artificial embankment, where it may be large; but that part of the escaping water which gets into the channel of the outlet canal is inconsiderable. If the percolation from these reservoir sites, estimated at 2,000 acres, was equal to that through the surface of the irrigated land of the valley, it would amount to 2 feet per second, or to 63,000,000 cubic feet for the year. It is quite likely that it is as much as this owing to the great pressure during that part of the year in which the reservoirs are well filled, and the average for each reservoir would be only two-fifths foot per second. This would make a total waste of 376,000,000 cubic feet, which is 288,000,000 cubic feet more than the river's estimated surplus. From the above estimates it is apparent that the average winter flow that can be utilized by the large reservoirs is inadequate to their needs. Besides this, it is not desirable, as a rule, to completely fill the reservoirs before the storms set in, as the spring winds drive heavy waves against the lower embankments, they being situated in the direction opposed to the prevailing northwest storms.

RESERVOIRS.

Besides the reservoirs mentioned there are a number of small ones, especially under the Larimer and Weld and the Cache la Poudre canals. Under the former the claimed storage capacity is about 175,000,000 cubic feet, and under the latter about 110,000,000 cubic feet. These reservoirs are used by one or more parties for storing the water from the canals when it is not needed, and to catch as much as possible when water is plenty. They have no independent means of drawing directly from the rivers. A number of reservoirs are in use, and more are projected that will obtain their supply from seepage water. One very large concern, the corporate name of which is the Windsor Reservoir and Canal Company, proposes to store 510,000,000 cubic feet in two reservoirs filled entirely from a ditch cut through a swamp made by irrigation.

Nearly all the reservoirs are connected with the four principal canals of the north side and are on the upper end of the canals. It happens that there is a series of depressions or basins naturally suited for this purpose in that part of the valley where they can be of most use. Farther east the land slopes gradually to the southeast or in the general direction of the dry creeks outlined on the map (fig. 2). In this lower end of the irrigated area the soil, though deep, is underlain by a heavy body of gravel, which gives good drainage and prevents waterlogging. Such a formation would be very undesirable under a reservoir, since, if not puddled, it would allow the water to waste by percolation.

In the reservoir region the soil, which is a stiff clay, lies directly on argillaceous shale. About 7 miles north of the river, near the lower end of the valley and on the ridges between the valleys of the dry creeks, the Laramie coal-bearing formation is found, and it extends thence northwest of Eaton, at which place alone it is mined. The depth to the coal is about 75 feet through clay, for the most part, the coal having a shale roof. The formation is dry here, but to the west is wet by the extensive irrigation practiced above.

The basins which have been utilized as reservoirs appear to have been formed by flexures or faults in the strata, and not by erosion, since in cutting the outlets the rock is found in the lower edge of the rim higher than it is toward the center of the basin. This rock is practically impervious to water. When the rock is wet, the water takes a lateral course over its upper layer, the clay next to it becoming quite soft and even disposed to slough off where a cut is made. This is the weak place in the structure of reservoirs on these sites, and has caused alarm on the part of people living under them.

There are now more reservoirs in the valley than can be filled with the available water. As a consequence the owners are asking that laws be passed fixing more definitely the time of year when water may be stored in preference to being used for irrigation. The regulations

now require that water companies keep their canals running for the use of consumers from April 1 to November 1, except during the time taken for necessary cleaning and repairs. The reservoir law provides that any person shall have the right to take from natural streams of the State and store away unappropriated water not needed for immediate use, for domestic use, or for irrigating purposes. The general theory is that when growing crops need water for irrigation the person having such crops has a right to it superior to those wishing to store it for future use, even though the works constructed for storage purposes antedate the canal supplying such growing crops.

The superior rights for immediate irrigation is supposed to exist especially during the seven months that canals are required to be kept running, even though the water is being used only for moistening the soil for the mechanical purpose of enabling it to be more easily plowed or for storing up moisture for next year's use. The owners of a canal that has no reservoir constructed on purpose to store water for its use in times when it is not needed for irrigation may well claim that the soil on their farms answers such a purpose, and that they have as good a right to run water onto these farms whenever they can as the owners of canals with reservoirs have to run it into the latter. These parties insist that the only time when they can be prohibited from using water is the one in which nature withholds it from them, namely, when it freezes so hard that they can not run it onto the land. This time differs so much in different localities of the State and is also so dependent on the character and situation of the works of diversion that it precludes any rules being laid down by the legislature.

If the canals now having reservoirs were without them, they would have a prior claim for use of the water after the crops were grown (provided they had a prior right for the irrigation of growing crops), and the fact that they have built reservoirs to store the water at times when it is not needed for growing crops should not, in the judgment of the writer, impair their rights to store the water instead of using it on the soil which is to play in part the purpose of a reservoir.

If such were the rule, every canal's right to water for storage for future use would have the same date as the rights of the canals of which they are adjuncts. The rule, however, is that reservoirs have prior rights to water for storage among themselves according to date of filing claims with the State engineer, provided the work be prosecuted with due diligence, irrespective of the claims of the canals to which they are adjuncts.

All the reservoirs in the Poudre Valley are adjuncts of some canal previously built, and are constructed to furnish such canals at times of scarcity in the river during the season that growing crops need irrigation. This is usually in the latter part of the season and for the potato crop, which is grown extensively, especially in the lower end of the valley. The quantity of water available for this purpose is, as

above stated, now exceeded by the capacities of the reservoirs, and parties are in court disputing one another's claims. It appears more likely that the courts will work out some generally recognized rule than that the legislature will be able to pass any law of general application, since the different irrigation localities hold diverse views and, indeed, have diverse conditions to be satisfied.

NORTH POUDRE LAND, CANAL, AND RESERVOIR COMPANY.

The North Poudre or uppermost of the canals, though among the latest in construction—its appropriation being No. 97 in the district—was the first to avail itself of reservoirs. The necessity for storing water which could not be used in the irrigation season early pressed itself upon the attention of the proprietors, not only because this canal was among the latest to appropriate water, but because the North Fork, from which it takes its supply, does not head back so far in the Snowy Range as do the other branches of the Poudre, and hence its water supply fails or becomes low early in the irrigation season. With perhaps the exception of the Larimer County Canal, these reservoirs are of more vital importance than those of any other canal in the district.

The number of reservoirs recorded in the reports of the State engineer up to 1894 is four. The date of the filing of these is December, 1891, but it is claimed that work was begun in 1883, and contention is made that priority dates from the commencement of work rather than from the date of filing claim, provided the work has been prosecuted with due diligence and the water applied to beneficial use within a reasonable time. This question is still in the courts, but reasoning from the position taken in regard to canals, it may be inferred that the contention will be sustained. Without these reservoirs the canal would be worthless.

The quantity claimed for these four reservoirs is 330,000,000 cubic feet, or 7,260 acre-feet. The proprietors of the canal report, in all, 12 reservoirs, with a united capacity of 800,000,000 cubic feet, or 17,600 acre-feet; but these later claims come after those of other important reservoirs, which may exhaust the supply available for storage.

A dam of considerable elevation was required at the point of diversion from the stream to raise the water into the head of the canal. This structure was made of timbers and loose rock, both obtained close by, and has proved so far safe and durable, in spite of the fact that the engineer, Patrick O'Meara, had but little faith in so loose a structure, built in part of perishable material. At its head the canal has also about a mile of fluming, a large portion of which rests on the rock prepared for it along the edge of the mountain. This flume has recently been replaced, and has needed much repairing. The dam and upper part of the flume are shown in the accompanying view (Pl. XV).

VIEW OF DIVERSION DAM OF NORTH POUDRE CANAL.

In proportion to its capacity, this canal is the most expensive in the district, having some tunneling besides the fluming. The cost is said to have been $150,000, which probably includes some work on the reservoirs. This latter was mostly done by the "Hartford Trust and Loan Company," behind which stands the "Travellers' Insurance Company." This company furnished most of the funds, and soon came in possession of the work and the land under it, which is said to be 16,000 acres. The company has found it a most expensive investment. It is stated that for the twelve years the net expenditure over income has been at least $10,000 per annum, this including the work done on the reservoirs. The flumes rebuilt under the direction of Engineer J. C. Ulrich are said to be models in this line of construction. One of these[1] is 2,200 feet long and 25 feet wide at the upper end, gradually tapering to 15 feet at the place where the water acquires its maximum velocity. The side planks are bolted, instead of being nailed to posts, and at the lower end the flume is

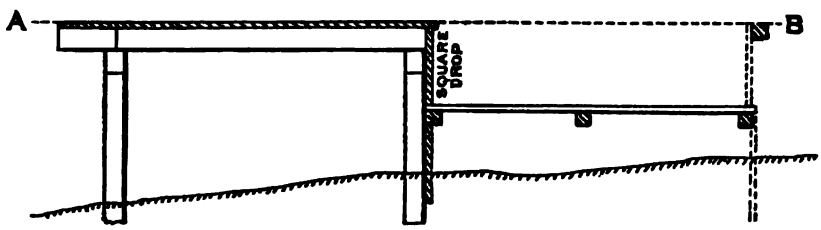


FIG. 7.—Vertical section of drop on North Poudre Canal. A B, line of canal.

given a perpendicular drop to guard against moving out, a tendency in flumes ending on the level with the canal below them. This ending of the flume is illustrated by fig. 7. In the new flumes all the lumber used is well seasoned and tarred, and this, in the opinion of the engineer, will much increase its durability.

The outlets of the reservoirs are deemed among the best in the State. They consist of iron pipes laid in Portland cement masonry and closed at the lower end by means of waterworks valves. In the larger reservoirs two pipes instead of one are used, to secure the easier operation of the valves. The fact that the means of opening and discharging the reservoir are at the lower end of the conduit pipes, and hence not covered by the water of the reservoir, as they are when either at the upper end or in the middle, is a great convenience and guards against numerous difficulties that attend operating under water. In the case of the North Fork Canal reservoir system a small discharge from each of its reservoirs into the canal will compensate for want of ample discharge in each separately.

[1] Annual Report of Am. Society of Irrigation Engineers, 1893, p. 188.

EXCHANGES OF WATER.

Besides the cases above mentioned, other friendly exchanges are made by the canals and reservoirs of different companies. During the season of 1895, Cache la Poudre Canal began to receive from the river widely fluctuating amounts, the quantity carried being on one day as high as 200 second-feet and on the next 25 second-feet. It is exceedingly difficult to distribute such a supply fairly to the consumers. In this emergency, the proprietor of the Windsor reservoir, just above the canal, allowed the water to flow through the Larimer and Weld Canal into his reservoir, and then to be drawn off in definite quantities for a definite time.

These civilities are the more worthy of notice, since all three of the parties have been and still are engaged in litigation as to their respective rights to storage water. Three suits have already gone through the district court and are now before the supreme court of this State. The claims of reservoirs to water for storage have never been subjected to a general judicial inquiry, like that given to claims of canals.

The law provides that when any party proposes to construct a reservoir he must send a notice, supported by affidavits, setting forth the name of the reservoir, the source of its supply, the name of its feeder, the time of commencing work on it, and its capacity in cubic feet. The data thus furnished is for the guidance of the river commissioner in allowing reservoirs to have water for storage, but may be attacked in court and claims there made good. In these investigations the time of commencing work gives precedence, provided work is prosecuted with due diligence, but the whole quantity that the reservoir can hold may not be granted as of date with the commencement of the work, provided some other party who began later has prosecuted work with superior diligence and has commenced to use before the first party was in a condition to store and use the whole of what he had claimed. Hence certain reservoirs in this district have a right to fill to a certain height and then fill to their full capacity after others are filled or partly filled. A record of the rights of reservoirs is gradually being had similar to that of canals, but these rights are in an inchoate state until the supreme court passes on them.

LEGISLATIVE AND JUDICIAL CONTROL OF WATER.

From the preceding statements regarding the canals and reservoir systems of Cache la Poudre Valley, the attempts made at water storage, and the complications arising, it is apparent that a considerable body of laws and court decisions must have been developed. It has been from this district, in fact, that many of the most perplexing water questions have arisen, and its public men have been foremost in the presentation and discussion of bills designed to protect irrigators in the enjoyment of the waters to which they are by use entitled.

VIEW OF NORTH POUDRE FLUME 300 FEET BELOW THE DAM.

Showing canal crossing the stream from which its waters are taken.

ORIGIN OF THE COLORADO SYSTEM.

The canals irrigating the lands of Union Colony were among the lowest taken from Cache la Poudre Creek. In the years succeeding the founding of the colony new canals were built higher up the valley and old ones enlarged. As a consequence, in the latter part of the year 1874, a time of unusual scarcity, the river was dry at the head of the canal that supplied the town, and there was great danger that trees, small fruits, and lawns would be ruined. A meeting was called, about 40 delegates representing the various irrigation interests being present. A proposition was offered to appoint a disinterested person to divide the water according to the necessities of the users, disregarding, for the present, priority of appropriation—a doctrine which was generally recognized, but which under the conditions then existing was found impracticable.

The men upstream would not listen to compromise, relying upon their advantage of position, nor would most of the Greeley people accept it, as they were afraid that the concession would be used as a precedent, and that they would thereby lose an undoubted right. Debate ran high. Threats of appeals to arms were freely exchanged. But at last the men above agreed to let down some water to save the most valued trees and shrubs in the town. The promise was not kept, and violence would have been resorted to but for a timely heavy rain, which both raised the river and moistened the parched gardens and lawns of the town and the fields in the country. From that day forth the people of Union Colony set their hearts upon having a law enacted to enable them to have the water of the river distributed according to the vested rights of all concerned. Still for some time no one outside could be led to take an interest in legislation of this kind, and the years 1875, 1876, and 1877 passed without anything being accomplished.

The constitution of the State, adopted in 1876, recognized in express terms the right of citizens to appropriate the waters of the State for beneficial uses, domestic, agricultural, and mechanical; but there was then no law to give this provision efficacy. Soon, however, other communities, especially the settlers on St. Vrain and Boulder creeks, encountered like difficulties, and the farmers around Fort Collins, who had at first opposed legislation providing for a distribution of water according to the rights of prior appropriators, began to favor it when they saw large enterprises inaugurated for the purpose of taking the water out of the river much higher up than the head of their canals, and thus threatening to deprive them of the advantage of position they had been enjoying.

IRRIGATION CONVENTION OF 1878.

As a result of the general appreciation of the need of State regulation and control, a convention of delegates representing the various

irrigation interests met in Denver late in December, 1878, for the purpose of formulating a scheme of irrigation legislation. Only the Platte Basin, now designated Division No. 1, was represented. At that time there was scarcely any irrigation carried on in those drainage basins that now constitute the other five irrigation divisions of the State. Indeed, it was not until 1885 that there was any effort made in other parts of Colorado to have the State control and divide the water, as provided in the act of 1879.

At the convention held in Denver the sentiment in favor of and against regulation by a State law was nearly evenly divided. Those from the districts where the supply in time of scarcity was exhausted were in favor of such regulation, while those who still had plenty of water were opposed, as they feared it would impose on them a needless expense. Others, especially lawyers, held that rights could be better secured through the courts.

It was finally agreed that a committee of five draft a bill for a law providing: (1) for the division of the State into water districts corresponding with areas irrigable from certain natural streams or portions of streams; (2) for the appointment by the governor of a water commissioner for each district, whose duty it should be to divide the water in his district according to a record of priority of appropriation, to be ascertained by some sort of judicial proceeding; (3) for regulations in regard to construction and right of way for reservoirs; (4) for the appointment of a State engineer and for gaging the streams of the State.

The committee, consisting of David Boyd, of Greeley, chairman; John C. Abbot, of Fort Collins; Dr. I. L. Bond, of Boulder; Daniel Witter and J. S. Stanger, of Denver, drafted a bill, which in its essential features became law by the action of the next legislature. The provisions, however, relating to a State engineer and providing for the gaging of the streams were rejected on the ground that it would be too expensive to the State, the agricultural interests of Colorado being then deemed insignificant. It became apparent by the time the next legislature met that little could be accomplished without a State engineer empowered to make measurements of water, and provision was accordingly made therefor.

DIVISION INTO DISTRICTS.

For the benefit of those who are studying the Colorado system or endeavoring to amend or improve State or local regulations it is proper to present some of the difficulties that beset this committee, of which the writer was chairman, in its attempt to draft a bill providing for the matters above named. One of the most perplexing things to determine was how much land should be embraced in an irrigation district or area within which priority of appropriation as conferring priority of right to use should be applied, and a record made as a basis of divi-

sion by the agents appointed for that purpose. Theoretically, such a record should embrace what is contained in one of the six grand divisions into which at a later date the State was divided.

The question was narrowed down to whether the whole South Platte and its tributaries within the State should be embraced in one record and be under one administration, or should be subdivided into a number of districts, for each of which a record of appropriations should be made without reference to the claims of the other districts of the division. It was finally decided that a record of the whole South Platte basin, covering so large a territory and embracing so many claims to water, would require for preparation an excessively long period, and that it would be almost impossible to execute the decrees, even when tabulated.

Eight of the districts now shown in Division I of the drainage map were then created. The first extended from the State line to the mouth of Cache la Poudre Creek; the second, from there to the mouth of Clear Creek, near Denver, taking in only the main channel of the Platte. Cache la Poudre basin was made the third and Big Thompson basin the fourth. St. Vrain Creek, except its main tributary, Boulder Creek, became No. 5; North and South Boulder creeks, No. 6; Clear Creek, No. 7, and the Platte above Clear Creek, No. 8. This latter was divided later into three, Bear Creek becoming No. 9, and all of the Platte above the canyon in South Park was numbered 23.

Recently district No. 1, which was about 150 miles in length, was divided into two districts, the lower one being numbered 64. South of this, Nos. 65 and 49 were created, both taking water from the upper forks of the Republican, which are dry creeks for the greater part of the year. Three other districts, which take their waters from the upper tributaries of the North Platte before they cross into Wyoming, were numbered 46, 47, and 48, and added to the first division. These five districts outside of the South Platte basin are relatively insignificant from an agricultural point of view.

In carrying out this scheme of districts, each with a separate record and administrative officers, the results were favorable as regards Nos. 3, 4, 5, 6, 7, and 8, each of which had an independent permanent supply from the mountains; but they were not so in numbers 1 and 2, which were wholly dependent upon streams passing through the six districts first named. The trouble was first felt in district No. 2, in which are situated the earliest ditches of the State, and which is supplied almost wholly by the streams embraced in what originally were Nos. 7 and 8. The vicinity of these latter to the city of Denver led to great development in the way of irrigation works about the year 1880 and thereafter, and when put in operation they soon exhausted the supply which district No. 2, on the Platte below Denver, had formerly received.

SUPERINTENDENTS.

The increasing difficulties in district No. 2 led to the enactment in 1887 of a law providing for division superintendents. The more important of the duties of each of these are as follows: Within thirty days after his appointment each superintendent of irrigation shall send notice to the clerk of the district court of counties in which judicial decrees have been rendered, fixing the priorities of appropriation, and shall request of the clerk a certified copy of every decree establishing such priorities. The superintendent shall then cause to be prepared a book to be entitled "The register of priorities of appropriation of water rights for division No. —, State of Colorado," within which he shall enter certified copies of decrees, and shall make out a list of all ditches, canals, and reservoirs entitled to appropriations of water within his division, arranging and numbering these in consecutive order, according to the dates of their respective appropriations within his division, and without regard to the number which they may bear within their respective water districts.

Water commissioners of the different districts are to report from time to time to their division superintendent the state of the water supply in their respective districts. From these reports he is "to ascertain what ditches, canals, and reservoirs are and what are not receiving their proper supply of water, and if it shall appear that in any district in that division any ditch, canal, or reservoir is receiving water whose priority postdates that of the ditch, canal, or reservoir in another district, as ascertained from his register, he shall at once order such postdated ditch, canal, or reservoir shut down and the water to be given to the elder ditch, canal, or reservoir, his orders being directed at all times to the enforcement of priority of appropriation, according to his tabulated statement of priorities, to the whole division and without regard to the district within which the ditches, canals, and reservoirs may be located." The district commissioners are subject to the orders of the superintendent, who may enter their districts and enforce his own orders if they are refused or neglected.

These rules read well, but they have been found impossible of execution. The water supply became deficient about the 1st of June, 1890. Many of the older canals in district No. 2 were empty, and an attempt was made to supply them by shutting down canals in other districts that postdated them. An order was given to cut off the supply of the Farmers' High Line and of four other large canals taking water from Clear Creek. The owners of these canals got a temporary injunction, which was afterwards made permanent, restraining the superintendent from shutting them off. The reasons given by the court for granting the injunction were—

First, that the superintendent did not have the necessary information from the water commissioner, in the form prescribed by law, on which to base his order.

Second, that the ditches in district 23, embracing the South Park, were not ordered closed to a date corresponding to those in the valley.

Third, that the law of 1887, which creates the office of superintendent and defines his duties, is unconstitutional, in so far as its effect is to determine rights of priority in the waters of the natural streams against persons who have had no day in court, by making the decrees rendered in one district binding and conclusive against claimants in another separate and distinct district who have also received decrees.

In regard to the first reason, it may be said that the kind of information required by the law to be obtained from the water commissioner to guide the superintendent in regulating the supply among the different districts of the division is difficult to procure from so wide a territory, and comes too late to aid him execute his trust with the promptness which the exigency of the situation demands. If a canal needs and is entitled to water to-day, it is usually ruinous to wait for ten days while the superintendent is getting the legal information, and hence the superintendent has to act, if at all, on the most uncertain and usually biased evidence.

The situation in district No. 23 may be examined somewhat at length, as it brings to light some interesting irrigation situations.

The water commissioner of district No. 23, after consulting with attorneys, declined to shut down any ditches whatever. The superintendent then made a personal inspection of the district, and endeavored to obtain the necessary information as to location of ditches, to enable him to close them down himself; but in addition to being unable to secure the needed information, he found that in the excited condition of the people it would require the State militia to enforce his order.

This was the last effort made to shut off the ditches of the South Park district, so far as the writer has been able to learn. The district is very large, containing about 2,500 square miles. The number of ditches reported is 209. Over 77,000 acres are claimed as under irrigation, all being native meadow land except about 300 acres. The quantity of water decreed to this land by the court is 4,665 second-feet—sufficient, if the ditches could carry it, to flood the area irrigated a foot deep every 8.7 days. Measurements made by the State engineer discovered the fact that many of the ditches fell far short of their decreed allowance, some receiving only about one-tenth of that amount.

It was, moreover, claimed by the users of water in this district that the early and heavy use of the water on the lands adjacent to the small streams that traverse the Park was a great advantage to the supply of the South Platte below its canyon, and measurements made by the State engineer seem to confirm this view. Nor is this unreasonable. This 77,000 acres of land is filled down to the bed rock with all the water the soil will hold by streams applied up to July. The irrigation is then stopped in order to cut and cure the hay. The water

rapidly seeps out of the pervious soil, increasing the discharge of the streams during the succeeding months. Assuming that the soil and gravel to the depth of 6 feet is filled with water, this will be equal to a depth of 2 feet of water, and the 77,000 acres would have a storage capacity of 154,000 acre-feet.

That this early excessive irrigation up to about July 1 has the effect claimed is borne out by the fact that the measurements of the waters of the South Platte as they pass through its canyon show it, on the average, to be much smaller than Cache la Poudre Creek at the season of high water, and considerably larger during the fall and winter months. A belief of this kind, together with the injunctions obtained in other cases where the superintendent attempted to shut water from canals of one district for the benefit of earlier ones in another, has hindered the superintendent from interfering with this or other districts.

CONSTRUCTION AND OPERATION OF CANALS.

The object of an irrigation canal is to divert water from a natural stream and take it where it can be spread over the land. Other things being equal, the shorter a canal is in proportion to the service it renders, the more economical that service. Some canals run as far as 20 miles before they can deliver any water, while others begin to deliver within a few miles of their heads. The length of a canal depends mainly upon two things, first, whether there are canals close below that cover the upper part of the lands below the new canal; and, second, the degree of abruptness with which the land rises as it recedes from the stream. If the slope or fall of the stream is great, then a canal that has a small slope will gain in the height of its bed over that of the river as many feet per mile at the end of a certain number of miles as the difference between its slope and that of the river. This height of its bed above the bed of the river will bear it far away or near to the river in proportion to the steepness of the land lying between the canal and river.

The slope of the upper part of Cache la Poudre Creek after it leaves the canyon is for a number of miles 15 feet per mile, which gradually changes to 10 feet per mile at its mouth, giving an average of about 13 feet per mile. Assuming that a canal like the Larimer and Weld is started within a few miles of the canyon on a slope of 2 feet to the mile and follows the contour of the country to the north of the river for 65 miles, and that the meanderings of the canal and of the river are about the same, it is evident that at the lower end of the canal it should be 715 feet above the river at a point on the latter opposite to this terminus. However, where this opposite point in the river is to be taken is really determinable only by measuring down the river a distance of 65 miles, following all its meanderings.

The height of the Larimer and Weld Canal where it crosses the Denver Pacific Railroad, about 9 miles above the river, is 250 feet above the river crossing. The length of the canal to this point is

about 50 miles, and accordingly, estimating a gain of 11 feet to the mile, it should be 550 feet above the river. The railroad distance in the river valley from Greeley to the head of the Larimer and Weld is 26 miles, which, multiplied by the grade of the road, assumed as 13 feet, gives 338, and this reduced by the fall of the canal for 50 miles, namely, 100 feet, gives a height theoretically of 238 feet. Hence it is to be assumed that the fall given to the river is that of a comparatively straight line running up its valley, and not the real slope of its bed, which must be about only half as much, since the bed of the river is more crooked than that of the canal. In Lone Tree Valley, which terminates at the mouth of Cache la Poudre Creek, and which has a nearly uniform slope of 25 feet to the mile, the distance of the Larimer and Weld Canal from the mouth of the creek is 12 miles. This would give a height of 300 feet, which corresponds closely with the other estimates, this point in the canal being about 60 miles from its upper end.

These relative slopes must be taken into account when any irrigation enterprise is contemplated in connection with considerations as to the fall which can be allowed a canal of a given carrying capacity without wearing its bed. Other related questions come, as to the alignment of the canal, the straightening by cutting and filling, and increasing the velocity; also how far shall the earth removed in excavation be placed back from the edge of the cut in forming the embankments, whether there shall be two embankments or only one (on the lower side) where there is a fill, and where, if there is only one, the water will run far back on the opposite side.

The experience gained from the results of the construction of two canals in our valley by the same engineer is deemed of practical value on these points. Union Colony Canal No. 2 was given a grade of 3.2 feet to the mile, a depth of only 2 feet, and a width on the bottom of 12 feet at the head. The course was very crooked, keeping for the most part in the ground, neither cutting nor filling much; the earth was piled close to the edge of the lower bank, and no embankment was made on the upper side, however far back the water might flow. This was economical in construction, but wasteful in the long run. The slope was none too much for the canal at the size it was first built, but it was finally enlarged to some five times its original capacity. The sharp bends were of necessity taken out, thus shortening the course and increasing the slope. The upper side had to be embanked where the water flowed far back, in order to prevent the action of waves on the lower bank and waste by evaporation; also to allow of the canal being filled and emptied rapidly.

The result of these changes was a great increase in velocity and resulting wear of the bed, which has now to be checked wherever water is taken from it. Portions of the bed not influenced by these checks are being worn away, and hence are in a condition to permit

great loss by percolation. The lower bank has been allowed to remain where it was, but should have been set well back, because wherever there is much wear on the lower bank there is great danger of break. The expense of moving the earth back some 6 feet is insignificant compared to the advantage of having it there.

The experience gained in the construction of Cache la Poudre Canal was of value in laying out the Larimer and Weld Canal some eight years afterwards. In general the slope planned was only 2 feet to the mile except for a mile and a half near the head, where the bed of the canal was over large bowlders similar to those in the bed of the river at the same place and where the fall was 15 feet to the mile. This part was given 13 feet fall to the mile, and has stood the wear without being materially moved. The lower bank was set back some 6 feet and usually made broad enough to allow the driving of a wagon along its top. Cuts and fills were made to some extent to preserve the alignment from abrupt angles, care being taken, however, not to cut too deep when this would prevent the water from being taken onto the land near the canal. Small expansions of the canal on the upper side were prevented by an upper embankment, except at Lake Lee, described on page 39. This serves a useful purpose for storing small quantities received from the river in time of scarcity to be delivered to alternate sections of the canal in amounts that can be economically applied. Another expansion of this kind near the lower end was found to be wasteful in times of low water, and a canal has been cut around its lower margin to keep the water out of it except when there is a surplus. On the whole, this canal has too much slope for its present size, and usually must be checked where water is taken into laterals.

CONTROL BY TELEPHONE.

This district is probably unique in the possession of a special telephone line for water control. This line was erected in 1889, being in part paid for by the two counties of Larimer and Weld, and in part by the large canals. It cost $1,500 and is an annual expense of about $60. The river commissioner regards it as worth each year its entire cost to the several users of water.

Its upper terminus is at the head of the Larimer County Canal; thence it connects with La Porte, where the river commissioner lives, some 4 miles above Fort Collins. It has two connections with offices of canal companies in the latter place, one each at the head of the Larimer and Weld and Cache La Poudre canals, two in Greeley, and one in Lucerne.

At three different places, at three set times, the river commissioner can be communicated with by those having the irrigation affairs of the district in charge. At the head of each of the three principal canals a man stays day and night, and the bell of the telephone is close to his ear when he is in bed. If there should be a sudden rise

of water in the river and the commissioner is notified of it, he can immediately communicate with these three men at the head of these canals and have them raise their gates to save it. If a break occurs in a canal, the party who discovers it can communicate with the man at the head by going to the nearest telephone station and have the water shut out in the shortest possible time, decreasing the damage.

The river commissioner must visit the gaging station daily to see how much water is in the river, this being his guide for supplying the different claimants according to their priorities. The station has a self-registering apparatus which gives the different heights to which the water rises during the twenty-four hours, and from the height in the channel the number of feet per second is found from a table experimentally prepared by the State engineer. The section where the measurement is made has masonry sides and a natural rock bottom, which give a definitely fixed cross section. Means of gaging every canal diverting water from the river are required to be put in by the owners, and these gagings are rated by the State engineer for the benefit of the river commissioner. Some of the smaller canals neglect to do this, and their water supply is estimated by the commissioner.

LATERALS.

The water is taken out of the canals by means of lateral ditches placed at short intervals. Usually they follow the crest of the ridges, and deliver water on both sides by means of sublaterals. Some of these laterals are very large, as, for example, those from the Larimer and Weld Canal. These carry as much as 100 second-feet, and in some instances have two ditch riders to distribute the water to the consumers. The laterals run as far as possible on the crests of the ridges that divide the valleys from one another, and the conditions in regard to their location are such that they can not be given any slope desired but must conform to the fall of the ridge followed. The average slope of the land between the canals and the river is about 25 feet to the mile. Hence, in general, the lateral has a fall as great as that. This will not cut very badly under a flow of a few feet of water, but with 100 second-feet, as with two laterals of the Larimer and Weld Canal, there is nothing to do but to put in drops here and there after the cutting has gone on for some time. These are built of 2-inch plank nailed to suitable timbers. It is deemed best to have a lower horizontal section of planked bottom and to give the water a forward instead of a sloping downward direction when it resumes its course in the channel of the canal.

MEASURING AND DIVIDING WATER.

From the main lateral, if it be a large one, the users divert water one or many at a time. It is measured to them, or a proportionate part of it set off for them, wherever it is deemed best. The quantity

taken in by the lateral is estimated by the main canal ditch rider. Usually the measurement is made over a weir some distance below the head, and is computed from a table furnished by the State engineer, applying accurately, however, only to weirs put in according to the Francis plan. Large discrepancies are found in some of these weirs by accurate measurement. Usually more water is given than intended, as conditions for controlling velocity of approach are rarely present.

The Larimer and Weld Canal uses weir measurements. By its contracts it is bound to furnish 1.44 cubic feet per second for each 80-acre water right if this amount can be had from the river. In the other canals measurement is not necessary, since the consumers are at the same time owners of the canals and each has a proportionate right to all the canal can or does carry. Hence equitable division is all that is required. The usual course to effect this is to give for each water right so many sectional inches. This is fair, provided the sections

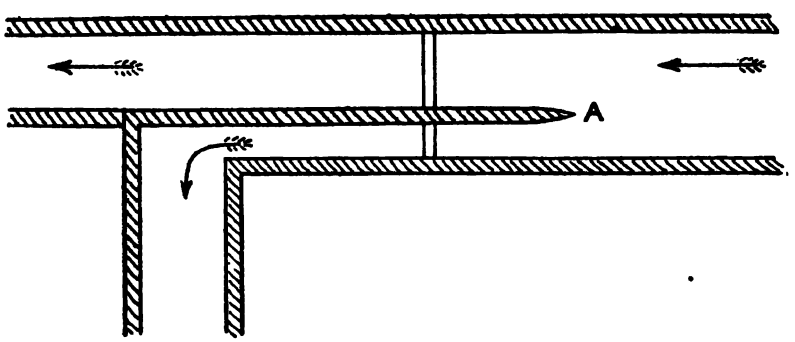


FIG. 8.—Plan of device for dividing water.

are of the same depth and the velocity of approach to the place where the section is measured is the same. The first condition can usually be secured, but often is not, and there is no uniformity in conditions to secure equal velocity of approach.

In the Cache la Poudre Canal devices called Max Clark boxes were put in both to measure and make a fair division. It was a modification of the Italian Soldati modulus, and at least did something toward making the velocity of approach to the measuring apertures uniform. It is not practicable to place a dividing device cutting off a proportionate portion of the whole in a large canal at each place where water is diverted, nor is this found practicable at the upper end of large laterals, but in the lower ends of these, and in laterals in general carrying not more than 25 second-feet, it can be done quite satisfactorily. A very simple and common form of divisor[1] is shown in fig. 8.

The partition at A is movable and may be placed at different distances from the side. When there is no desire to change the relative

[1] Measurement and division of water, L. G. Carpenter, Bulletin No. 27, Colorado Experiment Station, August, 1894, p. 9.

quantities taken through the two openings, the partition is fixed. This is usually the case, as it prevents changes being readily made by dishonest parties. When this partition is fixed, alterations can be made to suit parties by putting in a perpendicular strip of board in one side or the other. The view in Pl. XVII shows a device in laterals of Greeley Canal No. 2 by which the stream is divided into four parts.

COST OF IRRIGATION.

It has been impossible to obtain reliable figures concerning the cost of all of the canals and ditches taking water from Cache la Poudre Creek, but, as stated on previous pages, the expenditures in the construction of the two larger canals are shown approximately. The first of these, the Cache la Poudre, as stated on page 32, cost $112,000, and its reservoir $110,000; in all, $222,000. The cost of the Larimer and Weld has been placed at $150,000 for the canal, and for the two main reservoirs, $165,000, this including the estimated cost of completing the Windsor Reservoir. The total cost of this canal and its reservoirs is thus $315,000, and for the two canal systems, $537,000.

The total area of land in crops under these two canals, not including that designated as waste and pasture land, is 66,349 acres. This number of acres divided into the cost as just given gives an average of less than $9 per acre for the water. The price originally paid the railroad company for the land was $3 per acre, making a total first cost of land and water of $12 per acre. Until about 1895 this land, with water rights, has been considered as worth on an average $40 per acre without buildings. As a rule, the lands have actually been held at a higher figure than this.

Omitting the other two large canals on the north side of the river, viz, the Larimer County and North Poudre canals, a comparison of the cost and value of the remaining irrigating ditches would compare favorably with these figures, except in the case where the lands under some of the ditches have been injured by excessive seepage and by the rise of alkali. If, however, these two large canals are considered, a different estimate must be made. Both of these were built after the supply in the river was practically exhausted and when extraordinary expenditures had to be made to secure a supply.

The Larimer County canals on the plains cost about $90,000, the part in the mountains approximately the same, $90,000, and the two main reservoirs $24,000. Estimating the cost of the other reservoir at $10,000, the total is $214,000. With this expenditure, only 16,713 acres were reported in crops, making a cost per acre for water of about $13, or 40 per cent more than in the cases above cited. Besides this larger cost, the land under the canal, on account of uncertainty of supply, has a relatively small value, dependent largely upon the success of the Sky Line Canal. If this and the reservoir system

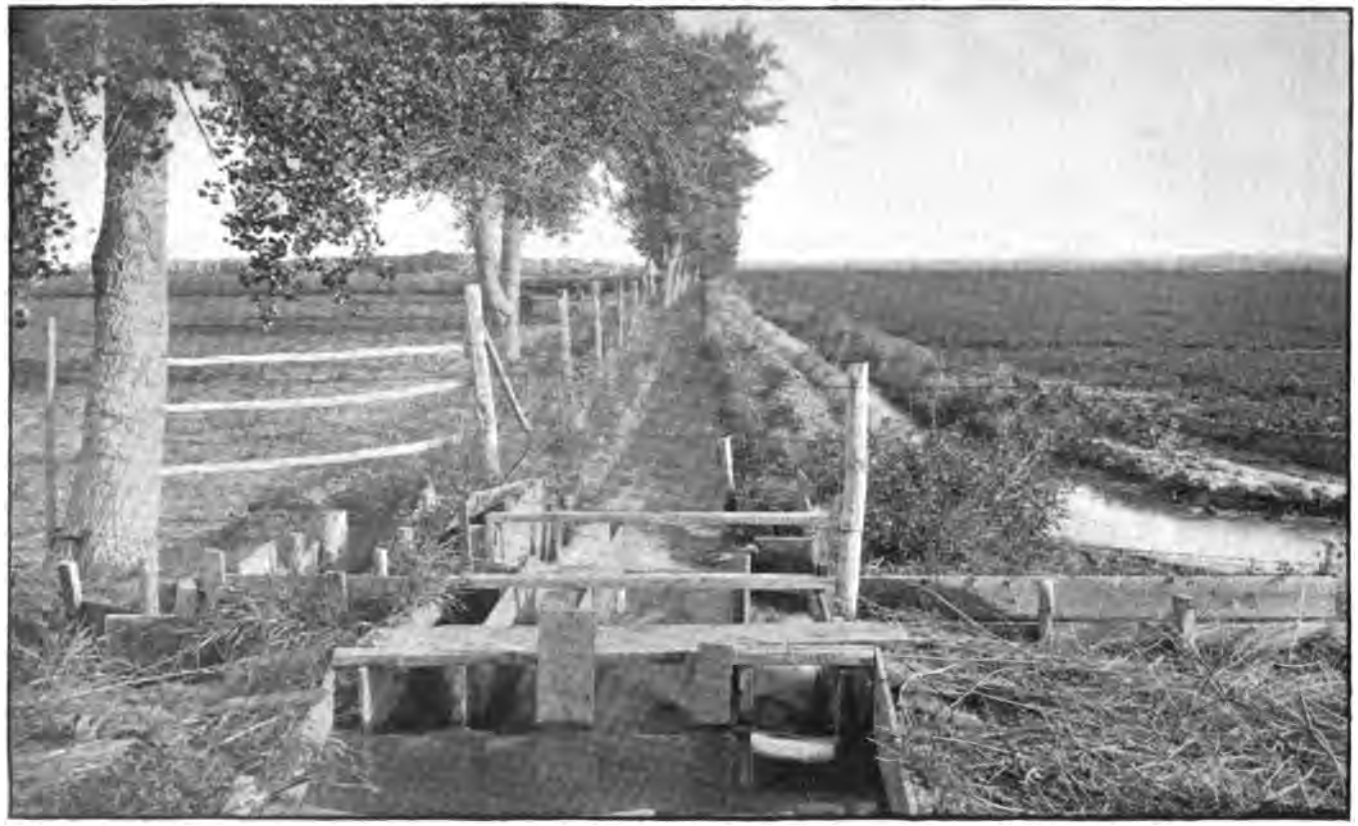
result according to the anticipation of their projectors, the lands will be as valuable as those under other canals. The unfortunate condition of the North Poudre Canal has been mentioned on a preceding page, its financial success being dependent largely upon the possibility of diverting some of the headwaters of Grand River into Cache la Poudre Valley, in a manner similar to that of the Sky Line Ditch.

As to the cost of maintenance, it may be stated that the three principal canals of the valley employed each three riders, and there is also one man at the head and a general superintendent. The cost for supervision for the years 1893 and 1894, as reported by the river commissioner for this district, was $17,502, and the cost of repairs for all canals having superintendents was $52,472. It is assumed that these figures relate only to the expenses of the canals and not to the laterals. Taking the length of the former at 333 miles and the area in crop as 125,000 acres, the cost for superintendence and repairs per annum would be 28 cents per acre.

AGRICULTURAL PRACTICE.

Whenever sufficient water is obtained and applied at the right times, the products of the lands within this valley are remarkable. Fertility is, however, maintained largely by a judicious rotation of crops. The best practice is that in which about one-third the area is kept in alfalfa, to be plowed under after two years' use as a meadow. Both the upper and lower ends of the valley are excellent for small grains and alfalfa, but the lower part is best for potatoes, and the upper for apple orchards, of which a great acreage has been planted within a few years. The more clayey soil of the upper end of the valley renders it more retentive of moisture during the winter and early spring, and hence the trees do not suffer so much from dry winds and occasional hot suns as they do on more porous soils. Blight has been severe on all the fruit trees of the valley save plums, which do well everywhere in the State.

The farms of the Greeley colony under Canal No. 2, now known as Cache la Poudre Canal, are rarely smaller than 80 acres or larger than 160. The latter is regarded as the better size for profitable farming if the owner does not get too heavily into debt. The interest at 8 per cent and the yearly payment of installments on a large farm are a heavy load even for this fertile valley, and are a fixed sum, while the profits are uncertain. The operating of the larger farms is more profitable from the fact that as much farm machinery is needed for the 80 acres as for the larger tract. If the farmer is raising grain, alfalfa, and potatoes, he needs three distinct lines of machinery. A good equipment of these and all kinds of implements needed to turn and stir the soil and move the crops will cost not less than $800. There is a much smaller proportionate investment for the larger than for the smaller farms.



VIEW OF DIVISION FLUME IN LATERAL UNDER THE GREELEY NO 2 CANAL.

The size of the farm which may be made the more profitable depends upon the man. If the owner is a good worker himself, but unskilled in handling men and in management, then the smaller farm will be best. Many men on an 80-acre farm have done well, made a good living, put up good farm buildings, and have money out on interest. Others have done equally well with 160-acre farms, one-half of which they went in debt for, while others undertaking this have lost all.

APPLYING WATER.

The farmer having his share of the water in his own little ditch carries it to the highest point on his farm and leads it either along the side, end, or obliquely across in straight or curved lines, so as to keep it where it can fill the smaller ditches. By these the water is carried, if possible, to every square yard of the farm. Often much diking must be done on the farm, and before the lateral reaches it, so as to get the main distributing ditch where it will cover the most land. These dikes are expensive to make and equally so to keep up, and are a source of perpetual annoyance and often of waste. A farm is to be preferred whose feeding lateral runs along one side and does not meander here and there. A farm with a sag anywhere in it, especially in the middle, is to be avoided.

The ideal surface for irrigation is one raised a little at one end or on one side. It should have a fall of from 15 to 25 feet to the mile, as uniform as possible, and in one direction. For an 80-acre tract the following conditions, if they could be realized, would be best: The upper shorter side should have a fall of about 5 feet to the mile for the feeding-head lateral, and the long direction a fall of 15 feet to the mile, with the lower short end having the same fall as the upper. It will be seen that the upper ditch, which is a quarter of a mile long, will have but a fall of 1¼ feet, and a dam put into it at intervals of 10 rods will make a difference of level of such a section of only 2 inches. If fifty rows of potatoes head into such a ditch and there is a sufficient volume of water in it to furnish a little stream for every row, it can easily be diverted into all at a time, since the diminished head will make up for the fall of level of the lower end of the bottom of the ditch, while, if the fall in this feeder was great, only a few of the rows close to the dam could be fed, and those unequally, without constant care and changing. This is the ideal surface slope for a potato field. Such tracts may be found north of Greeley and extending up to Eaton.

Such a surface is also desirable for grain or alfalfa, and to irrigate these crops by flooding, as is customary, the farmer has only to run through the grainfield or meadow a large double-moldboard plow, drawn by from four to six heavy horses, and penetrating to a depth of 12 inches, throwing a bank to each side and leaving a clean ditch behind it. These ditches are usually put a hundred feet apart, and

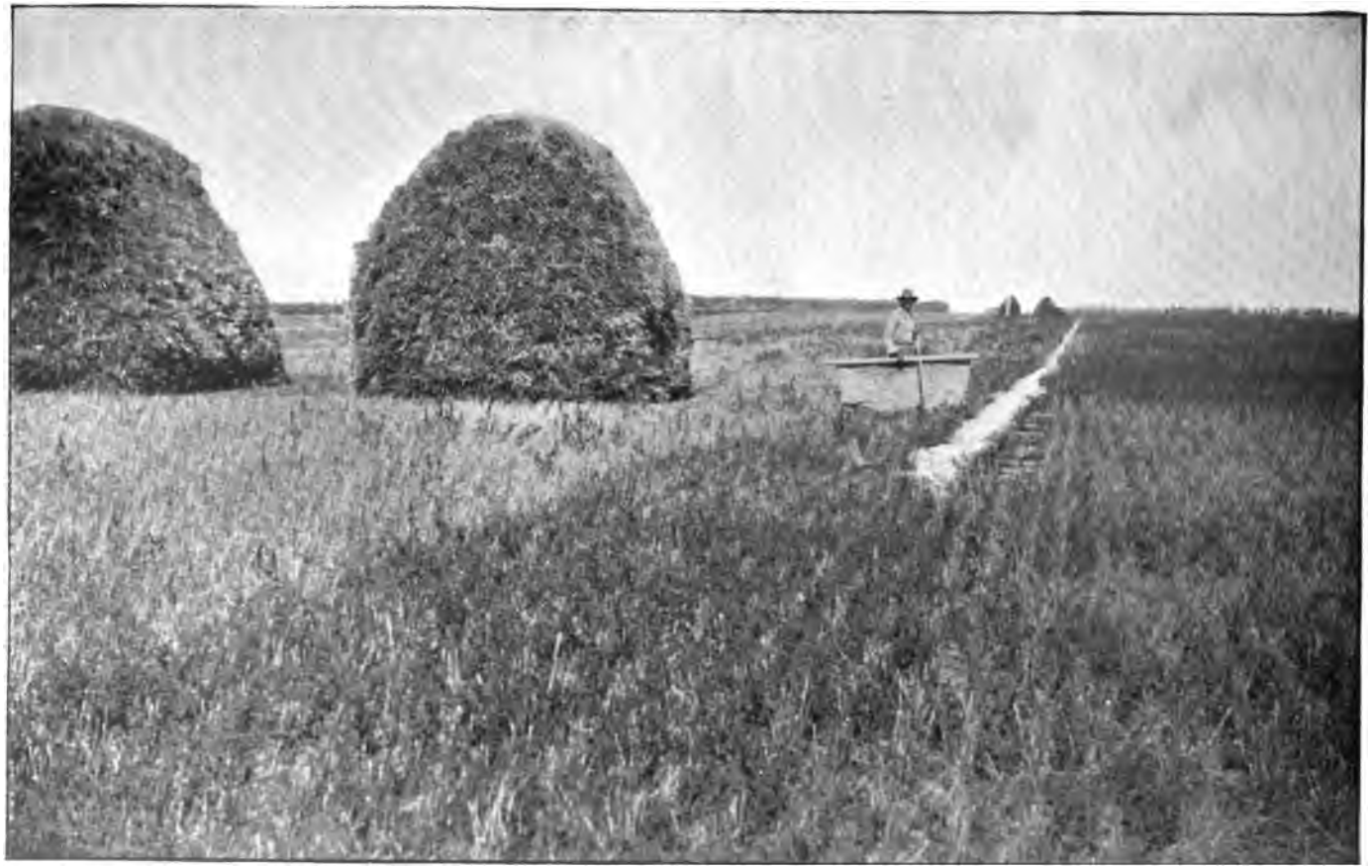
plowed in before harvesting, but in an alfalfa field they are left permanently. At suitable intervals a canvas dam is put into the ditch, the pole to which the edge of the canvas is nailed supported on both banks. The cloth lies in the bottom and on the edges of the ditch and is kept down by a little dirt put on the edge. The bank is cut on one or both sides as desired, just above the dam.

The use of the canvas dam is illustrated in Pls. XVIII and XIX. The former view shows a man with a canvas dam in his hand ready to put it in the lateral flowing through a field of young alfalfa. This view was taken on September 20, 1896, of a field under the Larimer and Weld Canal, near the town of Lucerne. On the left and in the distance are shown stacks of wheat recently cropped from the field. Pl. XIX shows the canvas dam in place turning out water for the irrigation of a wheat field near Greeley. The stream, checked in its flow, is forced to find its way into the young grain.

Little has been done in Cache la Poudre Valley in the way of leveling the land preparatory to irrigation. This is necessary only with rolling land, and especially where there is but little fall to it. Even when the surface is quite uneven, if there is considerable fall, a farmer can generally lead the water over the higher spots, while when it is nearly level it can be got onto these spots only by diking the ditches that run through the field. These dikes within a field are a nuisance, and in most cases it is better to level down the humps. For this sort of work various kinds of scrapers are used.

If a field is level to start with, it is important to keep it so and not create artificial irregularities by cultivation. This is done if the plowing is in narrow "lands," the "back" and "dead" furrows proving a great annoyance when flooding. To avoid these the farm should be divided into a suitable number of rectangular fields and each of these plowed out one year and in the next. The small rise or hollow where the corners occur will prove a slight annoyance, but the work of alternate years keeps the change of level within narrow limits. To not only keep the surface of his farm in good shape but to improve it is the care of every intelligent farmer managing an irrigated farm. The action of both plow and cultivator, if carefully directed, is to improve the level of the surface, and the irrigation of rowed crops contributes to the same effect. The loose material in the steeper parts of the rows is carried into slight depressions and left there, and in a few years these disappear. The perfect potato field is without such depressions, but a surface entirely free from them is rarely found. They are less objectionable in a cornfield, as a little flooding does it less harm than potatoes, and hence it is advisable to raise a few crops of corn at first in such fields, even if the crop is not profitable.

To raise a good crop of potatoes on a steep field requires great pains and ingenuity. If the surface is not wavy as well as steep, the rows



can be run diagonally across the slope, so as not to give them too much fall, which will make the bottoms wash away and lower the water surface, so that the rows are not moistened underneath. Some farmers run the rows directly down a steep slope, and in irrigating let a tiny stream trickle down between the rows for a day or two, and thus succeed in having the moisture penetrate the rows. To get the water to enter so many rows at once requires a very level head-feeding ditch, or the greatest pains and ingenuity in the way of checks to effect that end.

In general it may be said that steep, rolling, irregular land is much less desirable in a country that is irrigated than in one where it rains, and such a farm should be avoided, however rich the soil may naturally be. Still, if the soil is a pretty stiff clay, it may be irrigated without tearing it to pieces, even if rather steep; but in this case it is next to impossible to spread the water so evenly and thinly that the soil can absorb all that is applied, and hence usually a large portion of that used runs off into hollows and draws and is lost to the owner.

ALFALFA.

Alfalfa can be raised at a profit for $3 per ton in the stack in the field. The average weight of the crop is variously computed by those who make careful estimates at from 3 to 4 tons per acre for the three crops, and it costs from $1 to $1.25 per ton to put up the hay at the present reduced price of hands and haying implements. At these figures an income of $5 per acre can be safely estimated from land put down to alfalfa. Seed costing $1.50 will sow an acre. It is now usually seeded with the spring-sown grain, and if one does not want to plow it under for fertilizing purposes, a stand will last twelve years or more.

These figures differ widely from those given in Arizona and the Pecos Valley, New Mexico, where crops of 8 tons per annum and prices of $10 per ton are claimed. From personal observation the alfalfa fields near Phœnix, Arizona, do not show such luxuriance as those of Cache la Poudre Valley. In considering the price of alfalfa hay the true test is what it is worth to feed on the farm, and not its temporary local price when a country is being opened up. Such is the productiveness of this plant that if any considerable area is brought into cultivation the local market is soon glutted. Thus the only safe basis of price is its feeding value and the probable permanent selling price of the meat produced from feeding it.

By adhering principally to alfalfa raising and stock feeding, it will be seen, a fair rental can be expected from land, and $40 per acre would be a conservative price for such land. Large tracts of land can be handled economically by one management if alfalfa alone is made the crop, and hence men who possess farms of considerable size are drifting into this crop and find it more profitable in the long run than renting in small tracts for mixed husbandry. This latter practice is

sure to run down a farm in a few years, while alfalfa farming at once keeps the land clean and increases its fertility amazingly. The best and most profitable farming here is done by men who own a moderately large farm and practice a mixed husbandry.

POTATOES.

Potatoes are usually planted after plowing under alfalfa. Two crops can then be successfully produced. Some farmers raise the two crops in succession, while others raise a wheat crop between. The former is the better way, as the land is usually too rich for the wheat if only one potato crop is raised. Besides, it often happens that the raising of one potato crop does not entirely kill the alfalfa, in which case it comes up in the wheat next year and smothers it, making it difficult to harvest. Usually the second crop of potatoes is the better, as there is likely to be a larger stand than when so much growth of roots and stubble are turned under and partly mixed with the soil, since the latter dries out rapidly from the free circulation of the air admitted by this light material.

The breaking of a well-set alfalfa field is no trifling matter. It may be done with three heavy horses, but it is hard work for them, and they will not be able to break more than 1 acre a day. The writer prefers using five heavy horses—three in the lead and two on the end of the beam. They can go right along and plow 2 acres a day. Alfalfa roots are very large and strong when the plants have attained a full growth. They give a jerky motion to the plow and it makes hard work for horses' shoulders. A cast-steel plow is used, and the share is so tempered that a file can just cut it. It is hammered out thin at the blacksmith's shop when it gets too thick to file easily. The reason for filing, rather than using the hard, thin edge, as in other plowing, is that the edge needs to be rough as well as thin, or the roots will slip along the sloping edge of the share and not cut well. In breaking, the plowing is done from 6 to 8 inches deep. In plowing stubble the practice is to get down about 10 inches.

If water can be had, it is better to irrigate the alfalfa field before plowing. It will be dry enough to plant in three days if it has not rained meantime. It is usual to harrow down or run over with a packer and leveler daily, so as to retain the moisture as much as possible.

The planting is now done with an Aspinwall planter, which may be regulated to plant from 11 to 23 inches apart. Good seed is indispensable, and is often hard to get. Under our forced cultivation the tubers deteriorate rapidly in form and vitality. Often the sprouts, when they start in the spring, are no thicker than knitting needles. A thin, weakly stand is sure to follow from the use of such seed. Seed is shipped in from sections where they are grown by natural rainfall. In 1896 a carload was obtained from the divide lying

IRRIGATING A WHEAT FIELD.

between Denver and Colorado Springs, a high region where the rainfall exceeds that of the plains, and where it suffices in spots here and there to produce a moderate-sized crop without irrigation. A new supply of seed seems to be needed about every three years to keep the stock in good shape, but much can be done by careful selection of home-grown seed. Storage in a comparatively damp cellar or dugout is now believed to keep up the vitality of the tubers better than storage in a very dry cellar. The latter tends to induce dry rot by the time the planting is being done, which is from May 15 to about June 10.

Early planted potatoes usually do not thrive well in this climate. The soil is too hot in July for the tubers, and if an attempt is made to keep down the temperature by frequent irrigation, the vines usually blight, turning yellow, both stem and leaves getting stiff. It is better to delay all irrigation until about the first of August, when the vines are beginning to blossom and the small tubers are beginning to form. August is much cooler here than July, the nights are longer, and there is more light rainfall and cloudy weather, all of which are aids to irrigation.

Soon after planting and before the potatoes come through, they are cultivated as deep as the ground is plowed with a two-horse cultivator, the soil being thrown onto the rows. The cultivator is followed by a fine-toothed harrow, nearly leveling its work but destroying all weeds and leaving the ground mellow. Two more cultivations are given, the last one throwing up the earth around the plants. This cultivation is followed by running through either a large single shovel with wings or a lister which makes a clean continuous ditch, but not quite down to the depth of the plowing. The top of the ridge is from 10 to 12 inches above the bottoms of the furrows.

By about August the vines have made a fair growth from the moisture stored in the soil and the light rainfalls. The roots have spread beneath the surface in the soil moved by the plow, and many of them have penetrated the unmoved soil in search of water. This is a healthy and thrifty movement on their part, and they are in a good position to utilize the moisture furnished them by irrigation. Water is allowed to flow gently between the rows, a larger stream being allowed to enter the rows when the land is level, so as to force it through, but if steep, it must be allowed to flow long and slowly on account of washing, and the irrigations must be repeated oftener. On level land two irrigations are usually sufficient, while four are none too many where the ground is steep or where it is very porous.

No rules can be given about the frequency of applying water except the general one that the soil in the rows should not be allowed to dry through and through so as to arrest the growth of the tubers. If this happens, then they take a new start when water is again applied and throw out knobs and become abnormal in form.

The main crop is harvested from October 1 to October 25. Some medium early ones are taken up all through September, but these are usually too unripe to keep long. The Dawden Digger is mostly used (see Pl. XX). It requires a man and four heavy horses to run it, and if kept going ten hours can dig 5 acres. The picking is paid for by the sack, which holds about 115 pounds. The price now is about 5 cents, which includes sorting and sewing. A sorter is mostly used, a horse dragging one along for four pickers, with one man to shake it, set off full sacks, and put on empty ones. These will keep a man sewing. If the potatoes are good, these six men will pick, sew, and sort 250 sacks per day. These on an average can be had from 2½ acres if the crop is after alfalfa, but no such average is obtained from all the acres planted, even in the best potato district. The most experienced and careful men sometimes fail to get even a thrifty stand, and as much poor land, or steep and uneven land, is planted, the general average from all planted in the valley will not exceed 60 sacks to the acre.

It takes about two men and a team to haul in and store the 250 sacks, which are put away in the dugouts on the farms, the sacks being laid on their sides and piled up about eight deep. Many sacks, however, are disposed of at the various railroad stations, being either sold and shipped away or stored at the potato warehouses.

Pl. XXI is a view of the potato dugout of Mr. H. B. Eaton, in the town of Eaton. It is excavated about 3 feet deep, and earth put on top and at sides. Teams drive in and out on a gentle incline. Capacity, about 20,000 sacks of 2 bushels each.

To operate such a digging outfit requires 7 horses and 9 men. Calling the services of 7 horses equal to 3 men, we have an average of 25 sacks per man, or nearly 50 bushels dug, sorted, sacked, sewed, and put away in the dugouts.

Sometimes the potatoes are taken up unsorted and stored away in bulk in the dugouts. In this case, about a bushel is put in a sack, which is neither tied nor sewed but piled onto the wagons and then dumped into shoots from the outside. The sorting is then done in the winter and spring. The sacks cost about 4½ cents by the thousand.

For the last five or six years the price of potatoes has not exceeded 75 cents per hundred pounds, while in 1896 it was only 25 cents. They are now worth from 50 to 60 cents. The crop in 1896 was short, not much more than half that of 1894, because of very dry, hot weather in the early part of the season preventing a good, thrifty stand and vigorous growth before irrigation was commenced.

In general it may be said that the crop can be raised at a profit in an average year for 50 cents per hundred, sacked and delivered at the depot. The outfit of tools, including alfalfa breaking-plow, harrow, cultivator, planter, digger, and sorter, costs about $300. The digger is a short-lived machine, and needs, on about an average, $10 per annum for repairs.

VIEW IN A POTATO FIELD NEAR GREELEY.

In several years after the colony settled here there was a home market, and hence a high price, as the competition was between those raised here and those shipped in. But gradually the supply began to more than meet the home demand, and shipments had to be made into the towns on the Missouri River and into Texas. Here we came into competition with potatoes raised in Iowa, Minnesota, Wisconsin, Arizona, and sometimes Utah and California. Still, compared with those localities that do not irrigate, with which we come in competition, we have the advantage in a dry and hence scarce year, when the price is high. The size is larger and the quality usually better, and therefore we get a higher price in the same market, say by from 10 to 20 per cent. Hence we are likely to keep on raising large quantities of potatoes in this region and at fairly remunerative prices on the average. But the days for making large profits have gone.

UNDERGROUND WATERS.

The percolating waters of the valley are of considerable importance, although relatively small in quantity compared to the amount flowing on the surface. The matter of seepage water has been fully discussed by Prof. L. G. Carpenter.[1] There are, however, a number of matters in connection with the character of water and the means of bringing it to the surface that are of importance not only in this valley, but elsewhere.

ALKALINITY OF SEEPAGE WATERS.

Seepage waters are nearly always heavily impregnated with alkaline salts, and storage increases the percentage of these deleterious constituents. If a reservoir is only 15 feet deep, there would be during the summer over one-third evaporated. As the salts held in solution do not escape, the water in the reservoir will be far more saline than it was when received. If the water stored comes from the river near its head and has been but little mixed with the return seepage always impregnated with salts or alkali, its storage will not materially injure it for irrigation.

The effect on soil using alkali water exclusively is soon made visible by efflorescence on the surface. Hence it is prudent to use stored water alternately with that brought direct from the river by the canals. Then when the drainage is good it may be expected that sufficient quantities of these soluble mineral constituents will pass off, leaving the soil comparatively free. The lower, older canals are making on this ground objection to exchanging the river water for the reservoir water in the manner described on page 60. This is a serious question; for alkali is easily developed and with difficulty removed. There is practically no way of removing it but by procuring good drainage and applying plenty of fresh water to the surface,

[1] Colorado Agricultural Experiment Station Bulletin, No. 33, Seepage and Return Waters from Irrigation, by L. G. Carpenter, January, 1896.

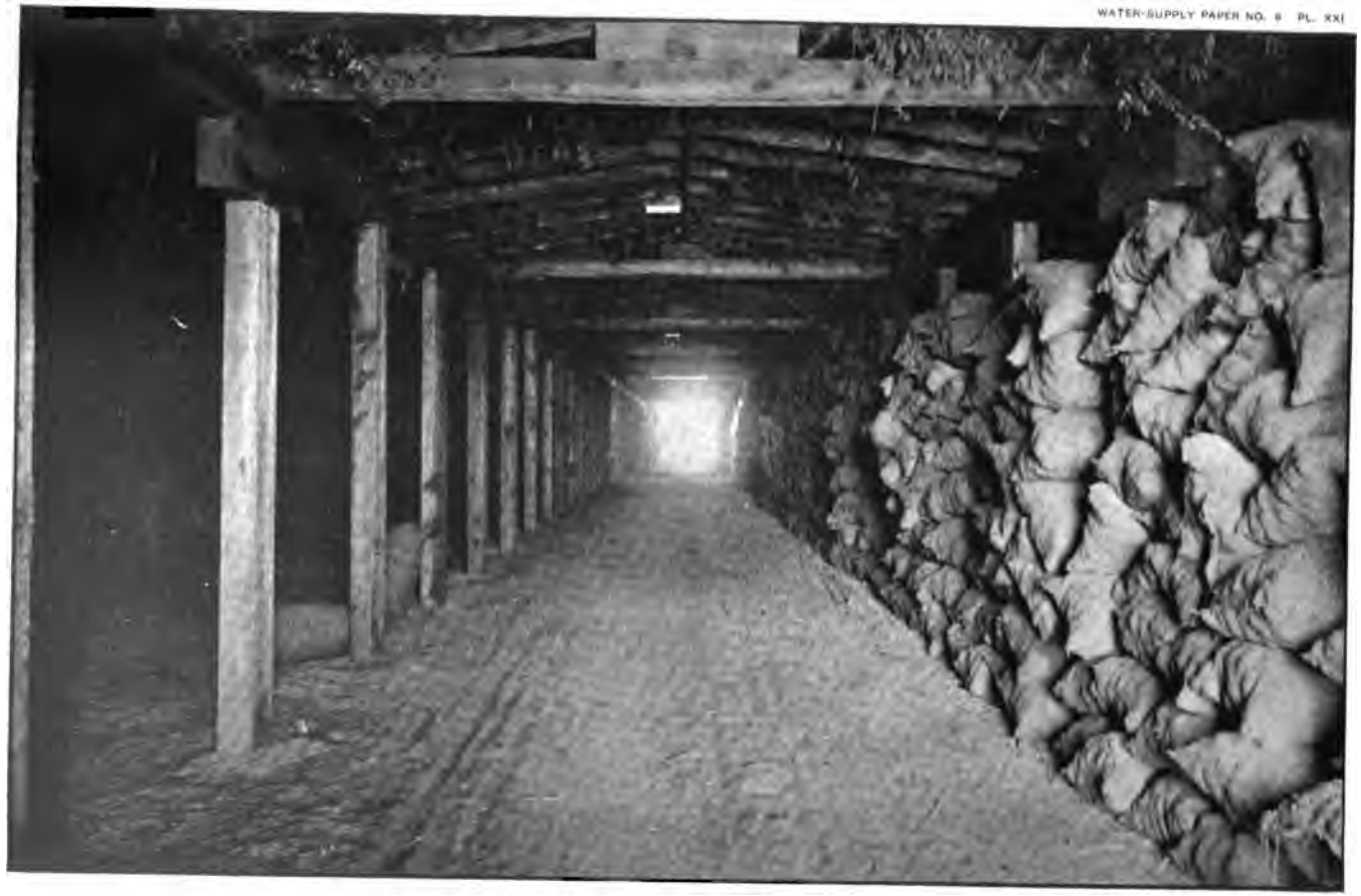
in this way dissolving and carrying off a share of it through the underdrainage. Surface flooding with fresh water will also help, but there must be good drainage, natural or artificial, or the land will be rendered too wet to raise a crop.

Little success has been made in reclaiming the wet alkali land in Cache la Poudre Valley, the most notable attempt being at the Agricultural College near Fort Collins. Here a swamp, made so by seepage water, has been deeply underdrained with tile, and the land now bears good crops. The writer undertook some work of this kind, which proved a failure because the tile were not laid deep enough to reach the sand or gravel, the chief outlet for the water that percolated through the soil. This is about 7 feet from the surface, and to tile land at that depth would cost more than the land is worth.

The drainage of the town sites of both Greeley and Fort Collins is of interest in this connection. When these towns were settled, there was no trouble in getting a dry cellar. After irrigation had been going on some three or four years, water commenced to rise in the cellars. In some of the lower places it showed itself even on the surface. Both towns are underlain with a deep gravel stratum, which it was believed would give a perfect drainage. The quantity of water applied in irrigating lawns especially, and by the great number of small ditches running nine months of the year, was more than the gravel could carry away, and so it began to force itself to the surface where lowest.

The town of Greeley first laid a deep drain on one side of Main street, extending to the river on the east and to the city limits on the west. It was put down 3 or 4 feet into the gravel. Sewer tile 18 inches in diameter was used without cementing the joints. This soon reduced the water level in the soil. There was a row of large trees along the side of the street whose rootlets penetrated the joints of the pipe and nearly filled it. This was all taken up and a larger pipe (at the lower end 2 feet) put in and the joints cemented, except at intervals of 200 feet, where manholes were left to let the water in and at which place the roots could be removed as occasion required. One cross drain was also put in, and now the drainage is satisfactory.

In the district immediately west of Greeley, and between its western boundary and Canal No. 3, water began to rise in the cellars, and about September 1, 1895, appeared on the surface a short distance west of the end of the town tile drain above described. The cause of this was traced to the removal from the bottom of the canal the winter before of the accumulated sand for the purpose of making mortar. When the water was let into the canal the spring following this removal, it was ascertained that several hours were required for the moderate volume to pass this disturbed area. The bottom of the canal is here a quite coarse gravel, allowing water to go through it like a sieve. The water could not be carried off by the drainage of the land



VIEW IN A POTATO DUGOUT.

below as fast as it went in. Prof. L. G. Carpenter[1] of the Agricultural College, states that a measurement of the amount of water in the ditch was made October 16, 1895. The quantity in the canal decreased from 25.86 second-feet above the place where the sand was removed to 20.80 second-feet a little distance below, or a loss of 5.06 second-feet. The total distance between the two measurements was about 760 feet. The total area of surface was about one-half acre. This would be equivalent to the discharge into the area wetted by the canal of the quantity covering it to a depth of 21 feet in twenty-four hours.

After the water was turned out of the canal, the cellars became dry, remaining so during 1896. Two years after the canal was originally constructed the same rise of the water in the soil was observed, but it disappeared after the sediment had coated over the surface of the gravel. The same effects of excessive percolation have been observed below canals of this district where the slope is so steep that the bottom is kept swept by erosion. When a check is put in, causing sediment to gather behind it, the percolation lessens or altogether disappears.

The drainage water of the city of Greeley is mingled with a limited quantity of sewage, which enters at the lower end of the discharge drain. This is carried across Cache la Poudre Creek in a wooden flume and is used for the irrigation of a market garden of about 200 acres. The quantity is approximately 5 second-feet up to about the end of the irrigation season, when it is more abundant. This drain affords an indication of the periodical fluctuation of underflow due to a change from ample irrigation to cessation. The strip irrigated is narrow, the canal not being more than from 1 to 1½ miles from the river, and the gravel bed deep and of coarse material.

PUMPING UNDERGROUND WATERS.

Nearly all of the water found in the soil and gravels comes from the percolation following irrigation. This is proved by the fact that the early wells dug in the valley often penetrated gravels without finding any water until the rock was entered. For instance, on the farm of the writer, in 1880, when the Larimer and Weld Canal was being built, a well was put down through 25 feet of soil, 25 feet of gravel, and 25 feet of shale rock. Here a thin layer of sandstone was found, yielding a small supply of hard, alkaline water. This well was about 6 miles north of Greeley, and its bottom was above that of the river, due south of it. Along the river bottom, which averages about 1¼ miles wide, water is found about on a level with that in the river, the sand and gravel underlying the soil admitting of its easy passage to and from the bed of the stream. The dip of the rock strata is toward the stream and slightly to the east.

The water in this well did not rise, indicating that there was no

[1] Seepage or Return Waters from Irrigation, L. G. Carpenter, Bull. 33, Colorado Agricultural Experiment Station, January, 1896, pp. 49 and 50.

pressure, or that the rock overlying this water-bearing sandstone was not impervious or water-tight, which was perhaps also indicated by the alkaline constitution of the water. After irrigation had been going on for two years, the water began to rise in the well, filling it up to the top of the rock and then gradually rising through the 25 feet of gravel. In five years from the digging of the well, the water stood within 25 feet of the surface, where it remains with but scarcely perceptible fluctuation. This is an example of what took place everywhere on the bench land, varied by the different conditions and depths of soil, gravel, and rock.

In Lone Tree Valley water was found at the bottom of the underlying heavy gravel bed, and an abundant supply is to be had above the Larimer and Weld Canal at a depth of 17 feet. The same condition occurs on Owl Creek, a branch that comes from the northeast. At Carrs Station, still farther north, on Lone Tree Creek, the water flows out at several places, presumably forced to the surface by the bed rock. At this latter point some small ditches furnish water to irrigate a few acres. Two wells, one pumped by steam and the other by a windmill, supply water for the irrigation of small tracts of land lying above the line of the canals.

Lone Tree Creek issues from the foothills at Granite Canyon, Wyoming. From there to the point where it ends in the Platte, at the mouth of the Poudre, is 75 miles. The watershed or catchment area has an extent of 536 square miles. The water found in the wells is quite soft, indicating that its origin is near the head of the creek. As the soil overlying the gravel is heavy clay, it is probable that but little of the rainfall penetrates it to any considerable depth, and is either evaporated or runs off from the surface into the bed of the creek. The surface run-off is an intermittent flow, but keeps its channel well defined.

In striking contrast are the conditions in this valley below the point where the Larimer and Weld Canal crosses. A short distance down the water flows permanently in the bed of the creek to such an extent that three or four small canals are taken from it. This water, unlike that usually seeping, is also quite soft, probably for the reason that the layer of soil above the gravel is thin, usually about 3 feet, and hence can furnish but little alkali to the water that percolates through it. The canal above is doubtless the principal source of the added underground water, since the bottom of its excavation must be near if not at the top of the gravel.

Two extensive pumping plants belonging to Andrew Wilson are located in Lone Tree Valley. The first is about 5 miles below the crossing of the Larimer and Weld Canal and 150 feet away from the creek channel. The depth to water here was 8 feet, and the well, 12 by 12 feet wide, was put into the water 10 feet. The well is cased with 2-inch plank, and was dug by machinery operated by a steam engine. The cost of well and two pulsometer steam pumps was $1,200.

The pumps raised a flow that, passing over a weir 2 feet wide, measured 5 inches deep. From this well in one year there were irrigated 240 acres, one-half in wheat, the other in potatoes. It took about 1 ton of coal per twelve hours, which cost at the Eaton mines, 2 miles distant, $1.50 per ton. The pump was operated night and day for about thirty days each season. This plant was erected in 1888, and the pulsometer pump was replaced in 1893 by one centrifugal pump operated by an engine, each costing $400. This is an improvement on the two pulsometers.

In 1892 Mr. Wilson put in another pumping plant, much more extensive, 2 miles farther up the creek. The well was put in a bend of the creek 93 feet from its bed. It is 12 feet by 12 feet wide and 27 feet in depth. Water here was found within 3 feet of the surface. The well cost $800, and the pump, engine, and boiler $1,700 more. The boiler is 60-horsepower, engine 35-horsepower. This pump, when operated constantly, can lower the water in the well 18 feet, leaving 6 feet still in the bottom. The pump is centrifugal and can in forty-five days raise enough water to irrigate 320 acres. It requires about 2 tons of coal a day. The coal is obtained at the same price and distance as in the first case. The owner considers this much cheaper than the purchase of rights in the Larimer and Weld Canal, in which, if obtainable, the cost is $2,000 per 80-acre water right from the canal and $800 per right for reservoir water, making an investment for water for the 320 acres of $11,200, as against $2,500 for the pumping plant. The expense of operation is considerably more, but not enough to equal the interest on the difference of capital invested.

The privilege of pumping water from his own land has not been continuously enjoyed by the owner. In the summer of 1895 he was restrained from pumping at the instance of parties who are diverting water from Lone Tree Creek below his plant. His pumps were stopped by the order of the district court about the middle of the irrigation season. He had already been through the courts in connection with his lower plant, and the case had been decided in his favor in the court of appeals at the spring term of 1893. This legal controversy is of general interest to those engaged in irrigation in the arid regions.

The district court in the first case instructed the jury as a matter of law "that water which percolates through the soil, without an evident and well-known channel, is regarded as a part of the land and belongs to the owner thereof, and he may make such use of the water as he sees fit while it remains on or under his land; second, that digging wells close to a stream, so that the waters of the stream necessarily percolates into such wells, thus diminishing the water previously appropriated, is but doing indirectly what the law forbids being done directly, and will not be allowed."

The verdict was for the defendant, because the evidence did not appear to the jury to prove that the pumping lessened the flow in

Lone Tree Creek. The court of appeals sustained the verdict "because the evidence was so vague, conflicting, and indefinite." But the court criticises the first instruction to the jury cited above in this fashion:

It is probably safe to say that it is matter of no moment whether water reaches a certain point by percolation through the soil by a subterranean channel or by a surface channel. If by any of these natural methods it reaches the point and is there appropriated in accordance with law, the appropriator has a property in it of which he can not be divested by the wrongful diversion of another, nor can there be allowed any substantial diminution. To hold otherwise would be to concede to superior owners of land the right to all the sources of supply that go to create a stream, regardless of the rights of those who previously acquired the right to the use of water from the stream below. Strictly and technically, the instruction should not have been given. There were no facts in evidence upon which it could properly be based. But in view of the fact that nearly all the evidence was directed to the question of whether the water supply was diminished by the acts of the defendants, the finding of the jury that it was not renders the instruction harmless. The other instruction (No. 2) given by the court appears to embrace and clearly state all the law of the case.

The ditch owners apparently made two claims, one for the water visibly flowing in the channel of the stream and one for a part of the water in the gravel below, which they affirmed they had forced up by means of a dam sunk in the bed of the channel at the head of their ditch. The testimony went to show that the pumping did not reduce the visible supply, and it was not proved how much the invisible supply was affected. From the nature of the situation it can be seen that no temporary shallow dam could raise and force the subterranean water into the head of the ditch, which was about 6 feet above the water table.

The valley at this place is 2 miles wide, and the depth of the underlying gravel is about 30 feet. Even if a comparatively wide dam were put into the creek down to bed rock it could not force the water table to rise except to a very limited extent and not to approach the height necessary to enter the head of the ditch. The water after being elevated a few inches behind the dam would undoubtedly move around its flanks in the surrounding gravel. In regard to this aspect of the question the court said:

In the case of a running surface stream the question of appropriation is of easy solution; but not so in a sunken stream, particularly where the water is at an indefinite distance below the surface. Under such circumstances it becomes at once apparent that to appropriate and utilize the water an impervious dam must be constructed and carried down to an impervious base to stop and retain the subterranean water and raise it to the ditch. Whenever such adequate provision is made, any act diminishing the quantity that would naturally reach the dam and add to the supply up to the limit of appropriation, whether by diversion upon the surface, the sinking of wells, and using pumps or otherwise, would be actionable. * * * It is in evidence that the plaintiff had constructed a dam across the stream to supply his ditch, but there is nothing in regard to the character of the dam. * * * The efficiency of the dam to stop, retain, and apply the sunken water should have been shown, for if the water found and taken by defendants

by sinking wells and pumping would, in its natural course, have passed under the dam [and he might have said around it] the available supply could not have been materially diminished.

The second case involved both wells, but has more pertinence to the upper one, which is much deeper and placed in a bend of the creek where the water was near the surface. In this case it was shown that the pumping decreased the visible supply in the creek above the heads of the ditches.

On hearing the question of making permanent the temporary injunction which he had granted, Judge Jay H. Bouton, of the district court, said: [1]

This is a case of great importance to all parties interested, and has been commenced at a very critical season of the year, and that is the reason why I thought it should be determined on its merits now. To my mind there is but one question of importance in this case, and that is as to whether the defendant, by the construction of these wells in Lone Tree Creek or its valley and the pumping of water therefrom, has diminished the flow in Lone Tree Creek so as to deprive plaintiffs of water to which they were justly entitled under their decrees as entered in this district; and perhaps preliminary to that is the question as to whether it is a well-defined stream, the water therein flowing in a clearly marked channel, either regularly or intermittently, from which the plaintiffs were entitled to their decrees of priorities. I am clearly satisfied from the evidence that both of these propositions must be answered in the affirmative. The testimony introduced on behalf of the defendant, standing alone, sufficiently establishes the fact that there was a considerable diminution in the volume of water running in Lone Tree Creek after the defendant's pumps were operated, produced evidently by sinking and pumping of water to irrigate his land. If that is true, then he has no more right to sink these wells below the level of the ground, or below the surface of the stream, and thus pump from the stream than he would have to take it directly from the bank [bed] of the stream for the same purpose by means of the construction of ditches. Of this proposition I have no doubt whatever. The motion to dissolve the injunction heretofore granted is denied.

It has been held by the court that if, as the result of pumping on one's own land, it can be proved that a surface stream is diminished to the detriment of one who has a prior right to the use of the water, it will not be allowed, no matter how the stream is fed—that is, whether it derives its water in part from percolation from the estate of the one employing the pumping plant or not. This reverses the doctrine that water mingled in the soil below the surface is part of the estate—the fluid substance being as much a part of the soil as the solid portion. In this case the true derivation of the water is not hard to trace. It is due both to the water flowing at the bottom of the gravel which underlies the valley and to the percolation from the Larimer and Weld Canal and the lands irrigated therefrom, and not to rainfall on the lands of the immediate vicinity. In consequence of this ruling there must be a great loss to this valley of water for irrigation. The quantity secured by ditches is insignificant compared with what could be pumped. The bed of the creek is nearly on a level with the top of the gravel bed, and hence can receive into its channel but a

[1] Third Colorado Court of Appeals, 430, and 33 Pacific Reports, 280.

very small portion of the underground water that is slowly moving along to ultimately make its appearance in the bed of Platte River.

Beginning in 1888 there was considerable activity in erecting pumping plants. A building was put up to manufacture what were known as the Huffer pump and the Nye pump. These, after trial, have been cast aside for the reason that the pumps did little work for the fuel consumed. They were simple in construction, and hence cheap, but they were of primitive design, dating back to the infancy of the application of steam to mechanical purposes. The Swan hot-air pump, devised by one of the men prominent in promoting pumping and the manufacture of the pumps above referred to, is perhaps as economical as any in the market. One of these has been erected on the banks of Cache la Poudre Creek, near Greeley, pumping out of the river for the irrigation of adjacent lands of H. E. Churchill. This was asserted to have a capacity of 1,000 gallons a minute, or about 2½ second-feet. The boiler was so constructed that it could burn coal slack, which cost about $2 a ton laid down, about a ton a day being required. Under usual conditions it probably lifted steadily 1½ cubic feet per second to a height of 15 feet. It was used three years, but was discontinued in 1896, the reason being given that the land cultivated was of poor quality and did not pay expenses, the price of produce being so low. Another of these pumps, raising water 30 feet, was used by J. D. Miller on his farm in connection with canal water when the latter was scarce.

ARTESIAN WATER.

As the lowest part of the valley—that at Greeley—is in the Fox Hills formation, there is little hope of striking the Dakota at moderate depths if the Cretaceous formation here is as thick as reported. R. C. Hills gives the average thickness of the beds lying between the Laramie and the Dakota at 3,500 feet. The latter sandstone outcrops behind the hogbacks near Fort Collins.

In spite of discouragements a project was started in 1883 to put down an artesian well in Greeley. Swan Bros. took a contract for drilling 800 feet. Blue shale was struck at 40 feet. No water was found at 800 feet that would overflow, and the work was prosecuted to 1,150 feet, when a fine bluish-gray sandstone was struck. The flow was quite weak, and it was decided to go farther to see if a better flow could be obtained. A depth of 2,300 feet was reached and no other flowing water was found.

Six others have been put down to this 1,150-foot water, all of which gave a weak flow until pumping was commenced in one, when the water ceased to flow in all the others. The water rises to within 40 feet of the surface. The cost of these wells to the depth of 1,150 feet is about $2,500. The water is distributed by pipes to the different parties that have put down the wells, and is highly valued for washing purposes. It is not hard, but contains matter distasteful to most

people. It was once regarded as medicinal in its properties, but now seems to have lost this reputation. The stratum of sandstone from which the water comes is about 25 feet in thickness, and on account of its fineness and hardness yields but a small flow.

Both in Greeley and in the country around it wells have lately been sunk into rocks believed to be of the Fox Hills formation. Soft water has been obtained, which, however, in no case rises to the surface. In Greeley the rock furnishing this water is struck at from 75 to 90 feet, and the water rises to within some 40 feet of the surface.

About 8 miles north of Greeley and 1 mile north of the town of Eaton an experimental well was put down by B. H. Eaton. The following account was obtained from the contractor, Dr. Swan: Above bed rock were 85 feet of soil and gravel. At 250 feet open, porous sand rock was found 30 feet thick, and in it a great abundance of soft water which rose to within 28 feet of the surface. At 450 feet a similar formation was found and the water rose to the same level. After this were shales and sandstones to 625 feet, but no overflow. At 625 feet blue limestone, 6 feet thick, was struck. The work was continued to 970 feet, but with no more sandstone nor water.

On the farm of the writer, about 3 miles south of the above, a well was put down in 1894 to a depth of 265 feet. Of this 55 feet were in soil and gravel to bed rock, the gravel being full of water to the top. Next below was a thin shale with coal indications; then a deep layer of sandstone, 80 feet thick, with plenty of hard water; then 40 feet of shale, underlain by 30 feet of sandstone, containing water, also hard; then 20 feet more of shale, when the sandstone was struck, which now yields the supply pumped from the well. The sand rock is very hard and close grained, and yields a small supply. The water comes to within 70 feet of the surface, but settles rapidly when pumped. There is 170 feet of 6-inch iron piping in the well. The total cost, pump and all, was about $500. Half a mile southeast of this well another was put down in which an abundance of soft water was found at the depth of 190 feet.

About twenty wells have been put down around the above two named within a radius of 3 miles. They vary so much in depth and in quality of water in the different sands as to lead to the inference that this country is much broken by faults and that at places the seepage water from the surface gets into the sandstone. In all the cases so far fairly soft and good drinking water is found in some of the sandstone strata and at a moderate depth, but the pressure in no instance is sufficient to make the water overflow, although it rises to varying depths from the surface.

These wells cost from $200 to $500 each, but furnish the best of drinking water, and have much improved the health of the localities where they are situated, especially in immunity from typhoid fever, the most fatal disease of this region. None of these deep wells have been put down more than 2 miles west of a line joining Eaton and Greeley.

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1895.

Sixteenth Annual Report of the United States Geological Survey, 1894–95, Part II, Papers of an economic character, 1895, octavo, 598 pp.

Contains a paper on the public lands and their water supply, by F. H. Newell, illustrated by a large map showing the relative extent and location of the vacant public lands; also a report on the water resources of a portion of the Great Plains, by Robert Hay.

A geological reconnoissance of northwestern Wyoming, by George H. Eldridge, 1894, octavo, 72 pp. Bulletin No. 119 of the United States Geological Survey; price, 10 cents.

Contains a description of the geologic structure of portions of the Big Horn Range and Big Horn Basin, especially with reference to the coal fields, and remarks upon the water supply and agricultural possibilities.

Report of progress of the division of hydrography for the calendar year 1893–94, by F. H. Newell, 1895, octavo, 176 pp. Bulletin No. 131 of the United States Geological Survey; price, 15 cents.

Contains results of stream measurements at various points, mainly within the arid region, and records of wells in a number of counties in western Nebraska, western Kansas, and eastern Colorado.

1896.

Seventeenth Annual Report of the United States Geological Survey, 1895–96, Part II, Economic geology and hydrography, 1896, octavo, 864 pp.

Contains papers by G. K. Gilbert on the underground water of the Arkansas Valley in eastern Colorado; by Frank Leverett on the water resources of Illinois; and by N. H. Darton on a reconnoissance of the artesian areas of a portion of the Dakotas.

Artesian-well prospects in the Atlantic Coastal Plain region, by N. H. Darton, 1896, octavo, 230 pp., 19 plates. Bulletin No. 138 of the United States Geological Survey; price, 20 cents.

Gives a description of the geologic conditions of the coastal region from Long Island, N. Y., to Georgia, and contains data relating to many of the deep wells.

Report of progress of the division of hydrography for the calendar year 1895, by F. H. Newell, hydrographer in charge, 1896, octavo, 356 pp. Bulletin No. 140 of the United States Geological Survey; price, 25 cents.

Contains a description of the instruments and methods employed in measuring streams and the results of hydrographic investigations in various parts of the United States.

1897.

Eighteenth Annual Report of the United States Geological Survey, 1896–97, Part IV, Hydrography, 1897, octavo, — pp. (In preparation.)

Contains a progress report of stream measurements for the year 1896, by Arthur P. Davis, and four other papers relating to hydrography. The first of these is by Frank Leverett, and relates to the water resources of Ohio and Indiana, especially as obtained by wells; the next is by N. H. Darton, on the artesian waters of South Dakota, being supplementary to his paper in the Seventeenth Annual; following this is a fully illustrated paper, by James D. Schuyler, on water storage, mainly for irrigation and the construction of dams; the last paper, by Robert T. Hill, describes the artesian conditions of a portion of Texas in the vicinity of San Antonio.

Water Supply and Irrigation Papers.

This series of papers is designed to present in pamphlet form the results of stream measurements and of special investigations. A list of these, with other information, is given on the outside (or fourth) page of this cover.

Survey bulletins can be obtained only by prepayment of cost as noted above. Postage stamps, checks, and drafts can not be accepted. Money should be transmitted by postal money order or express order, made payable to the Director of the United States Geological Survey. Correspondence relating to the publications of the Survey should be addressed to **The Director, United States Geological Survey, Washington, D. C.**

WATER-SUPPLY AND IRRIGATION PAPERS.

1. Pumping water for irrigation, by Herbert M. Wilson, 1896.
2. Irrigation near Phœnix, Arizona, by Arthur P. Davis, 1897.
3. Sewage irrigation, by George W. Rafter, 1897.
4. A reconnoissance in southeastern Washington, by Israel C. Russell, 1897.
5. Irrigation practice on the Great Plains, by E. B. Cowgill, 1897.
6. Underground waters of southwestern Kansas, by Erasmus Haworth, 1897.
7. Seepage waters of northern Utah, by Samuel Fortier.
8. Windmills for irrigation, by E. C. Murphy.
9. Irrigation near Greeley, Colorado, by David Boyd.
10. Irrigation in Mesilla Valley, New Mexico, by F. C. Barker.
11. River heights for 1896, by Arthur P. Davis.

In preparation:

12. Water resources of southeastern Nebraska, by Nelson Horatio Darton.

In addition to the above, there are in various stages of preparation other papers relating to the measurement of streams, the storage of water, the amount available from underground sources, the efficiency of windmills, the cost of pumping, and other details relating to the methods of utilizing the water resources of the country. Provision has been made for printing these by the following clause in the sundry civil act making appropriations for the year 1896–97:

Provided, That hereafter the reports of the Geological Survey in relation to the gauging of streams and to the methods of utilizing the water resources may be printed in octavo form, not to exceed 100 pages in length and 5,000 copies in number; 1,000 copies of which shall be for the official use of the Geological Survey, 1,500 copies shall be delivered to the Senate, and 2,500 copies shall be delivered to the House of Representatives, for distribution. (Approved, June 11, 1896; Stat. L., vol. 29, p. 453.)

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DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 10

IRRIGATION IN MESILLA VALLEY, NEW MEXICO.—BARKER

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

IRRIGATION IN MESILLA VALLEY, NEW MEXICO

BY

F. C. BARKER

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, April 13, 1897.

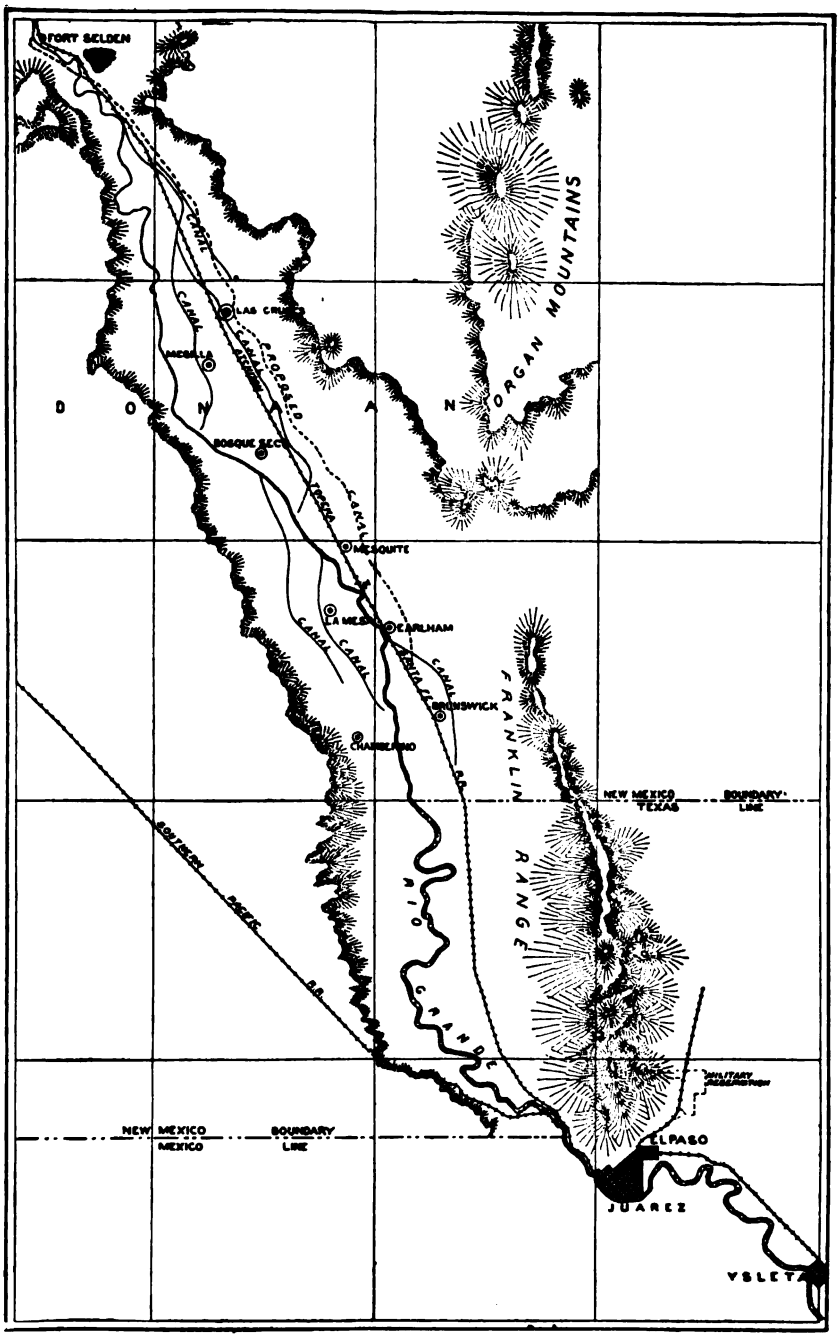
SIR: I have the honor to transmit herewith a manuscript entitled Irrigation in Mesilla Valley, and to recommend that it be published in the series of Water-Supply and Irrigation Papers. The statements therein contained have been condensed and rearranged from a somewhat detailed discussion prepared by Mr. F. C. Barker, of Las Cruces, New Mexico, and a few facts pertaining to the flow of the Rio Grande at El Paso have been added.

In this paper the methods of irrigation and cultivation in common use by the natives of the valley are discussed with a considerable degree of detail. For a full understanding of the possibilities of the development of the country, it is necessary to possess a general knowledge of the habits of the native population and to know something of the methods of agriculture which have been adopted, for, although these may not be the best, yet they are the result to a certain degree of the peculiarities of climate and soil. A thorough comprehension of the natural conditions which have led to the adoption of certain practices and their continuation through a long period of time is highly important. One of the greatest sources of loss and disappointment to the newcomer is the result of his unwillingness, in so many cases, to conform to practices that have been found beneficial through centuries and his attempt to introduce methods valuable elsewhere but unsuited to local conditions of land, water, and labor.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.



MAP OF MESILLA VALLEY.

IRRIGATION IN MESILLA VALLEY, NEW MEXICO.

By F. C. Barker.

LOCATION AND HISTORY.

Mesilla Valley is in the Territory of New Mexico, lying on both sides of the Rio Grande and between two spurs of the Rocky Mountains. It extends from Fort Selden, New Mexico, on the north, to within 3 miles of the city of El Paso, Texas, on the south—about 55 miles—and for the greater part of this distance it varies in breadth from 5 to 7 miles. Along its entire course it is bounded on the east and west by lofty ranges, the highest of which—the Organ Mountains, distant some 12 miles to the east of the valley—rise to a height of 8,000 feet above sea level, or 4,000 feet above the agricultural lands along the river.

The Atchison, Topeka and Santa Fe Railroad traverses the entire length of the valley, the principal station being at the town of Las Cruces, New Mexico, while the southern end of the valley is tapped at El Paso by the main line of the Southern Pacific, Texas Pacific, Mexican Central, and Galveston, Harrisburg and San Antonio railroads.

Along the Rio Grande are several other valleys, somewhat similar to the Mesilla Valley, but smaller. The nearest are those of Colorado, Loma Parda, Palomas, and Valverde on the north, and Ysleta Valley on the south, just below El Paso. The soil, climate, system of irrigation, and methods of farming are so identical with those of the Mesilla Valley that only a passing reference will be made to them. In all of them progress has been considerably retarded through lack of sufficient water, but with the building of storage dams along the river those to the north will secure an ample supply, while the Ysleta Valley is relying on the international dam which it is proposed to build at El Paso in order to furnish a constant supply of water to the Mexican Valley on the right bank of the river and to Ysleta on the left. With the building of these dams a chain of valleys, extending over 100 miles and unequaled in fertility and climate, will secure all the water needed and be brought under successful cultivation.

The methods of irrigation and agriculture as practiced in the Mesilla Valley are, so far as I have been able to ascertain, the oldest that exist in the United States. The system established is of especial interest to

the student of farming under irrigation, as much may be learned from the native Mexican farmers, whose fathers and forefathers have practiced irrigation from the time the Spanish Jesuits settled in Mexico, more than three hundred years ago, and taught the subjects of Montezuma the art of agriculture. The Spaniards had themselves been taught how to farm with the aid of irrigation by the Moors, who held southern Spain from the eighth to the fifteenth century, and who, in the early part of their occupation of that country, laid out those magnificent irrigation works which exist to the present day. Having passed several years of my life in Spain, I have had abundant opportunities of studying the ancient systems of irrigation as there practiced, and during a long residence in the Mesilla Valley I have been able to compare the two systems, which I find almost identical.

Although there is abundant evidence that all this part of the continent was densely populated in prehistoric times, little or nothing is known of the Mesilla Valley prior to the year 1841 beyond the fact that an attempt was made in 1825 to colonize the valley by citizens of Old Mexico, and that the enterprise had to be abandoned owing to the hostility of the Apache Indians, who infested the country.

In 1841 the Mexican Government at Juarez, a town on the Rio Grande, opposite El Paso, and now the northern boundary town of the Republic of Mexico, was induced to give to its citizens grants of land in the Mesilla Valley. Two reasons led the Government to adopt this course. In the first place, the valley of the Rio Grande around Juarez had become thickly settled and land was getting scarce; in the second place, the Government was anxious to establish a settlement higher up the river, which might serve as an outpost to stop the incursions of the Apaches.

In that year some fifty families of native Mexicans from Juarez were tempted by the fertile lands of the Mesilla Valley to form a settlement, and these people built a town at Donna Ana, from which the county afterwards took its name. Here they took out a ditch or irrigating canal from the river, and introduced the methods of irrigation and farming which had been practiced for three centuries in their native homes. These pioneers ultimately became a thriving community, but in the beginning they had to face continual danger from the neighboring Indians, and while one squad worked with their spades another stood on guard with loaded rifles. Finally the home Government had to send troops to give additional protection, and the whole valley was then rapidly settled, so that when the Americans took possession it was already known as the "Garden Spot of New Mexico."

After the Mexican war that portion of the valley lying west of the Rio Grande became part of the territory of the United States under the Guadalupe-Hidalgo treaty, dated February 2, 1848, but it was not until the year 1853 that this Government acquired the eastern part of the valley, under the Gadsden Purchase.

United States troops were then stationed at Fort Selden and Fort Fillmore, and at Mesilla was another army post, effectually protecting the valley against the attacks of the warlike Apaches. Several Americans now settled in the valley. Mesilla was made the county town, and through it passed the postal service and overland freighting outfits to Arizona and California. These conditions, added to the remunerative contracts which the settlers were able to make for the supply of grain, food, and fodder to the United States troops, often at most exorbitant prices, made Mesilla a thriving business center, and, as more irrigating ditches were built and an extended area of land was brought under cultivation, the whole valley became abnormally prosperous.

This state of affairs, to a great extent artificial, was, however, doomed to come to an end. In the year 1881 the Atchison, Topeka and Santa Fe Railroad commenced to build its line from Colorado down to El Paso, Texas, along the banks of the Rio Grande and through the Mesilla Valley. The town of Mesilla was then lying on the west bank of the river—which has since changed its course, leaving Mesilla on the east bank—and its citizens were approached by the promoters of the railroad with the view of ascertaining what facilities and inducements they would offer the railroad to pass through that town. The leading citizens, however, foreseeing that the railroad would destroy their profitable freighting business and ruin the monopoly of trade which they enjoyed, replied that they did not want a railroad within 80 miles of their town, and did everything in their power to drive it away.

The Southern Pacific Railroad contemplated making a junction at Mesilla, but met with similar discouragement, and ultimately chose El Paso. In the meantime the people of the little town of Las Cruces, more farseeing than their neighbors, arranged with the Atchison, Topeka and Santa Fe Railroad to pass through their town, with the result that since that time Las Cruces has been gradually growing in population and importance, while Mesilla has been left in the state of a "deserted village," although many still live in their fine houses and beautiful gardens, established in the good old times, the passing of which they continue to lament. With the advent of the railroad came lower prices and fiercer competition, and this, combined with the defective system of canals, to which reference will be made later, resulted in much land going out of cultivation.

It is only within the last eight years, with the influence of settlers from other parts of the United States, that the valley has begun to recover from the effects of this sudden change of circumstances. The American farmers, while adopting the old Mexican system of irrigation, revolutionized the agriculture of the valley by planting large fields with lucern—or alfalfa, as it is called—and by the introduction of modern farming implements and improved American varieties of apples, peaches, and other fruits.

CLIMATE.

The altitude of Mesilla Valley is about 3,850 feet, the 3,900-foot contour crossing the river, as shown by the Las Cruces topographic atlas sheet of the United States Geological Survey, about 6 miles below Fort Selden, and sweeping down the valley and well up on the flanks of Franklin Mountains. The atmosphere is exceptionally dry, the days are sunny, and the climate as a whole is invigorating, so that the country is well known as a health resort, especially during the winter months. Although the sun is scorching hot during the summer, it causes little inconvenience, owing to the rapid evaporation of perspiration, which tends to keep the surface of the body cool. Sunstrokes are unknown and work in the fields continues without interruption. The thermometer, however, rarely goes above 102°, and the number of days on which it has gone above 100°, as taken from the records of the agricultural college, is as follows:

	Days.
1892	18
1893	16
1894	5
1895	2
1896	13

The nights, even in summer, are comparatively cool, and vegetation therefore makes but little progress until the middle of April.

Throughout winter the days are invariably bright and sunny. A light fall of snow usually occurs once or twice in the year, but disappears rapidly as soon as the sun shines. Notwithstanding that the thermometer falls much lower than one would expect, judging by the warm days, the low fall occurs only during a few hours preceding sunrise, so that the land is seldom frozen, and farming operations can be carried on almost every day in the year.

The lowest temperatures registered at the agricultural college in past winters are as follows:

	Degrees above 0, F.
January 14, 1892	4
December 31, 1893	9
January 7, 1894	2
December 29, 1895	1
January 5, 1896	9

The total rainfall in the year is exceptionally light, and occurs mostly in July and August, which may be considered the rainy season. The college records show:

	Inches.
1892	6.47
1893	10.91
1894	4.47
1895	9.46
1896	7.99
1897	8.96

These figures show how impossible it would be to raise crops without the aid of irrigation.

Light winds occur almost daily during the year, never sufficiently strong to do any damage. The maximum velocity registered at the college is as follows:

	Miles per hour.
1892	60
1893	48
1894	48
1895	60
1896	56
1897	60

With such a light rainfall the humidity in the atmosphere is naturally very small, and consequently dews are experienced very seldom, and only in a slight degree. The records at the agricultural college show that the average relative humidity was:

	Per cent.
1895 (last nine months)	68
1896	60
1897	72.8

WATER SUPPLY.

The main source of water supply is the Rio Grande, the water being diverted by small canals or ditches constructed on a gently descending grade following the contour of the country until they reach points at considerable distance from the river. The water from these can then flow upon the lower land down toward the main stream. A small quantity is also pumped from underground, as described later. As the methods of management of the canals, distribution of the water, and its application to the soil are governed to a considerable extent by the character of the Rio Grande, it is essential to have clearly in mind some of its characteristics.

FLOW OF THE RIO GRANDE.

This river rises in the mountains of southern Colorado and flows in a general easterly and southerly course through the broad San Luis Valley, entering the deep canyons of northern New Mexico. Here it receives numerous tributaries from both sides, and passes in succession through a number of narrow valleys in central and southern New Mexico, Mesilla Valley being the last of these. Leaving this, the river passes through the narrow gorge at El Paso and forms the international boundary between the United States and New Mexico. Measurements of the volume of this stream have been made by the United States Geological Survey near its head waters at Del Norte in Colorado; also at Embudo and San Marcial, New Mexico, and at El Paso, Texas. The results of these latter indicate the quantity of water which has passed through Mesilla Valley. For the details of river flow reference may be

made to the annual reports of this Survey, and especially to the progress reports of the Division of Hydrography.[1]

The first river station on the Rio Grande near El Paso was at Old Fort Bliss, about 1,500 feet above the Mexican dam. Observations and measurements were made here from May 10, 1889, until the end of June, 1893; but on the abandonment of Old Fort Bliss the river rods and equipment were stolen. A new station was established on January 24, 1895, at the pump house of the smelting works near the station Towne, on the Atchison, Topeka and Santa Fe Railroad, 1½ miles above Old Fort Bliss. The channel is of such an unstable character that no definite relation can be established between gage height and discharge.

Observations of gage height were begun on January 25, 1895, at which date the gage reading was 6.5 and the discharge 230 cubic feet per second. The water height fluctuated above and below this point during the month of February, and in March reached a maximum of 8.5, considerably more water being discharged in March than in February. The discharge during the months of April, May, June, July, and August was in general much greater than in the month of March; but only one measurement of discharge was made—that on July 19—which showed a gage height of 8.15 and a discharge of 1,039 second-feet. The average for August was something more than 1,000 second-feet; but from the first of September the river declined in volume irregularly until on September 25 a measurement showed but 76 second-feet, and at the end of that month the river was entirely dry. Very little water was discharged during the month of October, but in November it gradually rose almost throughout the month, reaching a maximum gage height on November 29 of 7.75, discharging perhaps 500 cubic feet per second. The discharge for the month of December fluctuated between 200 and 500 cubic feet per second.

Throughout 1896 the readings were continued. During the month of January the minimum gage reading was 5.85 on the first of the month, and the maximum 7.60 on January 17. A measurement made January 11, at gage height 6.15, gave a discharge of 150 second-feet. Another measurement on January 23, at a gage reading of 7.30, gave a discharge of 379 second-feet. The range during the month was probably between 100 and 400 second-feet. February maintained a somewhat higher average than this, though the maximum was probably not so great. March was closely comparable with January.

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[1]Eleventh Ann. Rept. U. S. Geol. Survey (1889-90), Part II, Irrigation, 1891, pp. 53-55, 99, 218, 222-223, 227.

Twelfth Ann. Rept. U. S. Geol. Survey (1890-91), Part II, Irrigation, 1891, pp. 240-290, 349-350.

Thirteenth Ann. Rept. U. S. Geol. Survey (1891-92), Part III, Irrigation, 1893, pp. 11-15, 94, 99, 114, 131, 137, 171-172, 411.

Fourteenth Ann. Rept. U. S. Geol. Survey (1892-93), Part II, 1894, pp. 110-115.

Eighteenth Ann. Rept. U. S. Geol. Survey (1896-97), Part IV, Hydrography, 1897, pp. 245-259.

Bull. U. S. Geol. Survey No. 131, Report of Progress of the Division of Hydrography for 1893 and 1894, pp. 41-46.

Bull. U. S. Geol. Survey No. 140, Report of Progress of the Division of Hydrography for 1895, pp. 169-186.

The months of April and May gave the largest run-off of any months of the year, with the possible exception of October. In the latter part of May and early June the volume of the river declined steadily until June 20, when there was practically no running water at the station, which condition continued to the end of the month. A slight rise occurred early in July, but lasted only a few days, and the river was then nearly dry until July 17, when a heavy general rain occurred, raising the water to 8.38 feet on the gage. The river was further swollen on July 24, and then declined until August 24, when it was again dry, and remained so most of the time until September 23, when it was again swollen by rain and increased in volume irregulary until on the 16th, 17th, and 18th of October the greatest discharge of the year occurred, the gage reaching a maximum of 10.6 on October 16, and declining by October 30 to 7.25 feet. During November and December the discharge varied irregularly from about 50 second-feet to about 300. The total discharge for 1896 was much less than for 1895.

Estimated monthly discharge of Rio Grande at El Paso, Texas.

[Drainage area, 30,000 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1897.						
January	1,260	90	305	18,753	.011	.010
February	230	125	194	10,774	.006	.006
March	120	30	72	4,427	.002	.002
April	4,225	40	1,740	103,537	.064	.058
May	17,000	5,000	8,312	511,085	.320	.277
June	11,000	2,000	6,095	362,678	.226	.203
July	5,300	300	1,330	81,778	.051	.044
August	600	0	132	8,117	.005	.004
September	2,880	0	705	41,960	.025	.023
October	5,000	230	1,758	108,095	.068	.059
November	1,695	810	1,132	67,358	.043	.038
December	1,015	460	680	41,812	.026	.023
Per annum	17,000	00	1,871	1,360,374	.847	.062

SUMMER DROUGHTS.

It will strike the casual visitor as strange that the Mesilla Valley, with the advantages of a soil almost unequaled in fertility, a climate adapted to all kinds of grain crops, alfalfa, and most of the choicest fruits and vegetables, and with proximity to remunerative markets, should have made so little progress in agriculture and that the country should have been so sparsely settled. The cause is the uncertainty of the water supply. For reasons which will be discussed further on, the Rio Grande, which furnishes water to all the irrigating canals, is liable to become quite dry at any time in the summer months after July 1.

This occurred in the years 1891, 1894, and 1896, although, with the exception of 1879, the country had not suffered from drought for many years previous.

There is a popular belief that these droughts are due to the great and increasing number of irrigating canals that are taken out of the river in Colorado and all along its upper course in New Mexico. That these must influence its flow lower down can not be disputed, but the general consensus of opinion among irrigation engineers is that, although the flow would be lessened during the period of irrigation, it would last longer, owing to the fact that a large portion of the water used in irrigation sinks into the ground and ultimately finds its way back into the river, which is the natural drainage channel of the country. Without venturing to decide this question, I believe that there are other and more cogent reasons why the river occasionally goes dry, and why it has done so with greater frequency during recent years.

It is an established fact that the river occasionally went dry in former years, when no irrigation canals existed along its upper course. This I know from numerous inquiries I have made among the old Mexican settlers. Moreover, history tells us that three hundred years ago Coronado, in his invasion of New Mexico, crossed the river, just

FIG. 1.—Diagram illustrating rise and fall of ground water of the valley.

above the Mesilla Valley, on dry land. Evidently, therefore, these occasional droughts may be traced to some other cause than the canals taken out higher up the river. This cause I believe to be the exceptionally small rainfall along the course of the river which precedes a year of dearth of water, and from all the information I have been able to gather this small rainfall has been especially marked of late years as compared with what it used to be ten or twelve years ago.

Owing to the peculiar manner in which the underground water is held in the valley, it is quite possible, and indeed certain, that a heavy rainfall in one or more years may make its influence felt for some years subsequently. To understand this it must be explained that there is not a point along the whole valley of the Rio Grande in southern New Mexico at which water in abundance can not be found at a depth seldom exceeding 14 feet, and there is good reason for believing that, even in the driest season, there is below the surface an underground flow which never ceases. It is also well known that in seasons of drought this underground stratum of water sinks very considerably, and I have been informed by some of the old Mexicans that at points where many years ago the water was to be found at a depth of only 6 feet it is now 14 feet below the surface.

VIEW OF RIVER AND NEW CANAL AT FORT SELDEN.

This supply of underground water is fed by the torrents of rain which frequently fall on the adjacent mountain ranges. Whether the ground water rises or falls depends upon these rains; and the extent to which the higher or lower level of this so-called underflow may affect the flow of the river is best appreciated by reference to the accompanying diagram, showing the position that the ground water may occupy according as its level rises or falls. The dotted line represents the level of the river bed. When the underflow is at the higher level it will be seen that not only does the open river practically flow over a body of water, but it may receive a vast increase from this source. On the other hand, when the level of the ground water falls beneath the level of the river bed, there will be an immense loss of water from the latter. How great the loss may be can be imagined when one takes into consideration the fact that this ground water averages probably several miles in width during the whole course of the river.

Of course the seepage from the river bed into the water-bearing strata below is very slow and gradual. Were it otherwise, the river would be continually disappearing below. I do not advance this theory as one that is thoroughly proved. A series of long and somewhat costly tests by experts would be required to prove it, whereas I have had to depend upon only such information as I have been able to gather during a long residence in the valley.

WATER STORAGE.

Hitherto the scarcity of water has not been so great as to injure the orchards and vineyards, and there has not been much loss, at least in the upper part of the valley, beyond an extra cutting of alfalfa or an occasional crop of vegetables. It is the fear of worse to come, rather than actual loss, which has prevented the investment of the capital necessary to develop the valley. There is, however, a remedy, and that is to build a dam and reservoir at one of the many available sites higher up the river. This would furnish a never-failing supply of water, as the surplus waters of the river during the flood seasons are more than sufficient to fill the necessary reservoirs.

With this object in view an English company has recently been formed and the capital has been raised in London. It is proposed to build at Elephant Butte, a point on the Rio Grande some 60 miles higher up the river than the Mesilla Valley, a dam of uncoursed rubble masonry, laid in cement, 96 feet high, which will form a lake capable, it is claimed, of holding 11,000 million cubic feet of water, or sufficient to cover 250,000 acres of land with 12 inches of water. The cost is estimated at $262,000. From this reservoir can be irrigated not only the Mesilla Valley, but also the valleys of Lomo Parda, Colorado, and Rincon, above. A smaller weir dam, which will rise 9 feet above the level of the river, is also to be built at Fort Selden, just at the head of the Mesilla Valley, at a cost of $75,000. This portion of the project is

to be completed first. With either or both of these dams many thousand acres of land now lying idle for want of water will be brought under cultivation, and doubtless a great impetus will be given to agriculture, and more especially to horticulture, in the Mesilla Valley.

QUALITY OF WATER.

Owing to the rich fertilizing ingredients which are contained in the muddy waters of the Rio Grande this river is often called the "Nile of America." Prof. Arthur Goss states[1] that the water adds to the land eight times as much potash as is required for either alfalfa or wheat, five times as much phosphoric acid as is needed for a crop of wheat, and nearly double that required for alfalfa. As regards nitrogen, the most valuable of all fertilizers, the water supplies more than double what is required by the wheat. It is true that it does not supply all the nitrogen required by the alfalfa, but there is every reason to believe that the water deposits more than is removed by this plant, which is capable of deriving most of its nitrogen from the air.

I am acquainted with land in the Mesilla Valley which for forty years has borne a yearly crop of wheat or corn, often both in one year, without application of any manure, and is now richer than when first cultivated. And in the valley below Juarez, where the same circumstances prevail, land has thus been cropped from time immemorial, probably for two hundred and fifty years.

Professor Goss says:

> There seems, on the whole, to be good evidence that the land here in the valley is practically inexhaustible when irrigated with sufficient quantities of the river water. In this connection might be mentioned the fact that fields of alfalfa can be found here which have stood for more than fifty years without being reset, and which produce as good crops now as ever. Mr. O. C. Snow, a large alfalfa grower here in the valley, states that he has produced excellent alfalfa from land originally consisting almost entirely of pure white sand, which would hardly produce anything before, by simply irrigating with the muddy river water, using large quantities at first to get a coating of the sediment over the sand and then seeding it to alfalfa and irrigating at the usual intervals.
>
> It is also unquestionably true that much of the land here in the valley has been cultivated for a very long time and is yet exceptionally fertile. It is also well known in the case of other rivers that the land upon which their sediments are deposited is inexhaustible. The Nile furnishes a good example of this fact, the land along this stream having been cropped for ages without becoming impoverished.
>
> Taking everything into consideration, it seems very probable, indeed, that fertile land in the Rio Grande Valley would never become so far exhausted as to produce very poor crops if sufficient muddy water from the river is applied to it. * * * As long as the river contains plenty of water the farmers in the Rio Grande Valley certainly have much for which to be thankful. Favored with a naturally fertile soil, they have the means at hand, in the ever-present sediment in the water, of permanently maintaining that fertility. With the small amount of rainfall, cloudless skies, and dry atmosphere the conditions for many agricultural operations, such as the curing of hay and ripening of fruit, are about as perfect as could be desired.

[1] Bull. New Mexico Experiment Station, No. 12. The value of Rio Grande water for the purposes of irrigation.

VIEW OF CANAL HEAD AT THE RIVER.

Add to this the fact that under a system of irrigation the water is under the control of the farmer, and one of the most uncertain factors in the agriculture of rainfall districts is removed. With a sufficient water supply agriculture in the Rio Grande Valley is about as nearly a mathematical science as it can be made.

CANAL SYSTEM.

It would, of course, be superfluous to describe to an engineer how the canals are built and the water is diverted from the river to the land without the use of any power but that of gravity, but it may be of interest to those who have never visited an irrigation country to learn how it is done. It must be understood that as the river flows down the valley there is a continuous fall in the land from the head of the valley to the other end. In the accompanying diagram, A is the head of the valley and B the lower end. Again, in almost all valleys there is a more or less rapid fall from the sides to the middle, where the river flows. Therefore there will be points (C and D) somewhere along the valley which will be considerably higher than the river at E and yet be a little lower than point A.

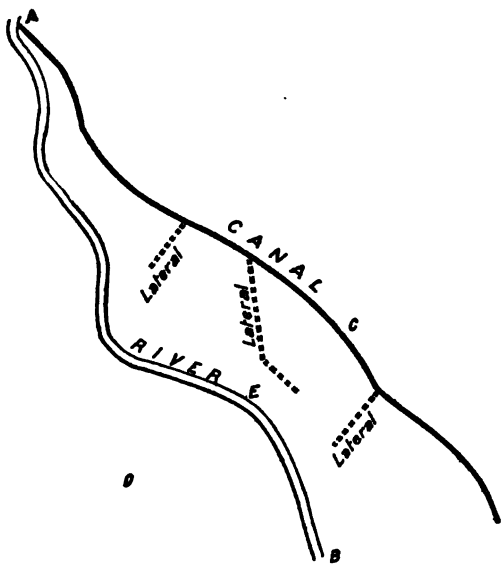

FIG. 2.—Diagram illustrating method of diverting canals from the river.

It follows that if the river falls, say, 1 foot in 100, and if a ditch or canal taken out at A is made to follow the contour of the side hills with a fall of only 1 in 500 it will very soon get higher than the level of the river, and that, as the valley widens and the canal seeks the higher ground, it will gradually get farther and farther away from the river, until by the time it has run, say, 8 or 10 miles, there will be a considerable space intervening between it and the river. It is this strip of land between the canals on the higher level and the river on the lower which is capable of irrigation. The head or inlet of a canal is shown in the accompanying view (Pl. III), the water in the river being obstructed in its course by a temporary dam of brush and stone. Entering the canal, the water flows usually on a gentle grade, and at convenient points is taken out by lateral ditches, which carry it to the fields.

Occasionally the canal passes over land where there is a sudden fall.

At these points mills driven by water power may be established. There are two such mills grinding wheat at Las Cruces, and others at Mesilla and Chamberino, although in recent years the millers of Las Cruces have found it profitable to supplement the water power with steam.

MANAGEMENT OF THE CANALS.

The irrigating canals or ditches in the Mesilla Valley, of which there are eight, are called locally by the Spanish name *acequia* (pronounced ah-sa'-ke-ah), and are what are termed "communal ditches;" that is, they were built and are owned, kept in repair, and regulated by the members of the community who hold lands under them.

On the first Monday in December of each year the co-owners of the ditch hold a public meeting and elect three of their members as commissioners, in whom the control of the ditch is vested for the ensuing year. These commissioners select one of their number as secretary, who usually receives a small salary, the other two acting, respectively, as president and treasurer without remuneration. A mayordomo, or water boss, is also elected by the people, and he, too, must be a co-owner in the ditch. He receives a salary ranging from $500 downward. It is his duty to superintend the cleaning and repairing of the ditch and also the distribution of the water, in which he is usually assisted by a second mayordomo, appointed and paid by the commissioners.

These elections are held under the management of the outgoing commissioners, and votes are cast in proportion to the amount of land held by each owner, or, rather, in proportion to the work he may be called upon to perform, for small vegetable and town gardens are assessed at about double the proportion for which farm land is liable. A farm of 52⅓ acres, which is called a *terreno*, the old Mexican division of land, is entitled to 6 votes, and so on in proportion, every owner being entitled to at least 1 vote, however small his interest.

The ditch must be thoroughly cleared of the accumulation of mud and sediment every year. This is usually done early in February, or as soon as danger of extreme frost is passed. When the time comes to commence work, the mayordomo notifies all landowners and tenants, and each one must perform his allotted share or number of days of the work, in proportion to the land he irrigates, or in default pay 75 cents per day. In olden times this notice was given out on the preceding Sunday from the steps of the Roman Catholic church door; but times and manners have changed.

In money this work usually amounts to 50 to 75 cents per acre, although sometimes, owing partly to mismanagement and partly to misfortune, it has been considerably higher. So far as I have been able to judge during my term of office as president of the Las Cruces ditch, I believe that in the future the total expenses will not exceed 50 cents per acre per annum. This economy is due largely to an act passed by the last legislature, which gives the three commissioners control, whereas by the old custom the entire management was left to the mayordomo, who, being

IRRIGATING CANAL IN THE MESILLA VALLEY.

practically unaccountable to anyone, frequently abused the confidence placed in him. By this act the treasurer and mayordomo are also obliged to give bond for the proper performance of their duties.

The method of assessing the work varies in the different ditches. By the old system the men were called out and kept at work until the ditch was cleaned and repaired, the owner of a farm of 52½ acres being compelled to do six days' work per week during the time consumed in cleaning and repairing, the owners of smaller tracts working a proportionately fewer number of days. A special cash assessment was made to pay the salary of the mayordomo and to cover other cash outlays, payable one-half after the wheat harvest and the other half after the corn was gathered in. This is the system still pursued on the Mesilla ditch.

On the Las Cruces acequia a different method prevails. At the commencement of the year the commissioners make an estimate of the amount of work and money required for the year. Each landowner is then assessed his proportion of days' work, or "fatigue," as it is called. He may do this work himself or employ others to do it, as he finds convenient, provided always that all his work is done within a certain limit of time, say three weeks; that is, if assessed eighteen days, he may work one man a day for three weeks, or three men for one week, or he may pay the commissioners in cash at the current rate of wages, which is fixed at 75 cents per day. As most of the Americans consider it beneath their dignity to work at digging mud from the ditch, they employ native Mexicans to do the work for them, or, as is often the case now, they pay the commissioners in cash, and out of this cash fund the salaries of the water bosses and other expenses are paid.

Each man on coming to work has a certain length of ditch allotted to him to clean out, which is called a *tarea*, and is, in the mayordomo's judgment, a fair day's work; but it often happens that a man is able to complete eight *tareas* in one week. The men usually work in gangs, for the sake of conversation and society. Most of the work is done with the ordinary short digging spade, but scrapers and teams are occasionally needed, and the only part of the work which the American farmer deigns to perform is to provide the latter. The amount of material removed is illustrated by the accompanying view, Pl. V, showing the accumulated material as thrown out upon the banks of a ditch.

Periodical meetings are held by the commissioners, when all claims, disputes, and complaints—and they are not few—are brought before them for settlement. If their decision is disputed, which most rarely happens, the case may be carried into court. In this respect the system is inferior to the old custom as it still exists in Spain. I well remember passing by the old cathedral at Valencia, on the shores of the Mediterranean, when the ditch commissioners were holding court under the cathedral porch. Three serious-looking Spanish peasants, dressed in the old Moorish costume and leaning on their long staffs, were gravely listening to the various claims and disputes brought before

them. Their verdicts, given rapidly and with decision, seemed to give satisfaction, for the judges were naturally well acquainted with all the circumstances, needing but few witnesses and no lawyers. From their decision there was no appeal. The system was perhaps rather un-American, but it worked well, and the people here still seem to retain their old traditional respect for the decisions of the ditch commissioners.

DISTRIBUTION OF WATER.

No scientific method of apportioning the water, either by measurement or by time, has been adopted in the Mesilla Valley. When water is abundant everyone helps himself whenever he needs it; and should it be scarce, as is sometimes the case, the mayordomos arrange to let each farmer have what appears to them a fair share, that share being fixed rather by the needs of the individual than by his share of interest in the ditch. For instance, in cases of scarcity of water preference is always given to the chili or red-pepper patches in the Mexican gardens, for a Mexican would die without his daily ration of chili.

The water is taken from the main ditch into the larger laterals, or

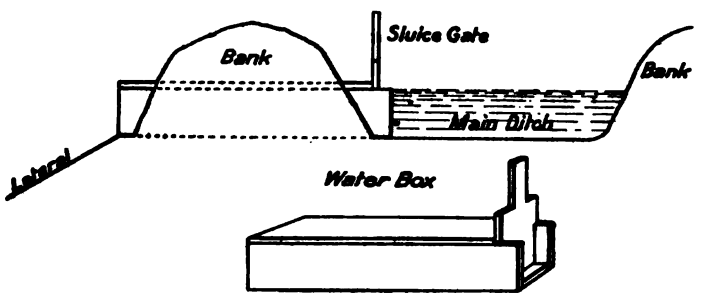

FIG. 3.—Box for taking water from main ditch.

contra acequias, as they are called, by means of flood gates, raised and lowered by a windlass. Usually the water is kept continuously flowing in the main ditch and main laterals, and the surplus is allowed to find its way back into the river or some lake at a point lower in the valley through a waste ditch or *desague*. The water is let out into the smaller laterals from the main ditch and larger laterals by means of boxes made of 3-inch lumber, with a head gate at one end, as shown in fig. 3. When this gate is lifted the water of course flows out, and when the necessary amount of water has been carried onto the land the gate is shut down.

METHODS OF APPLYING WATER.

FLOODING IN CHECKS.

In order to get the water upon the land, a side or lateral ditch is carried from the main ditch or larger lateral along the highest side of the land to be irrigated. The field is then laid out into squares or

VIEW OF DITCH, SHOWING ACCUMULATION OF SEDIMENT.

oblong beds—check beds, as they are usually called—surrounded by borders of earth about a foot high. These check beds vary in size from 30 feet square to 60 by 100 feet, according to the fall of the land and the crop to be irrigated. Of course if the fall of the land is great the check beds must be correspondingly smaller.

The water is let into the first bed from the lateral ditch, either by means of a box and gate, as already described, or by breaking down an opening in the bank with a large hoe. As soon as the first bed is

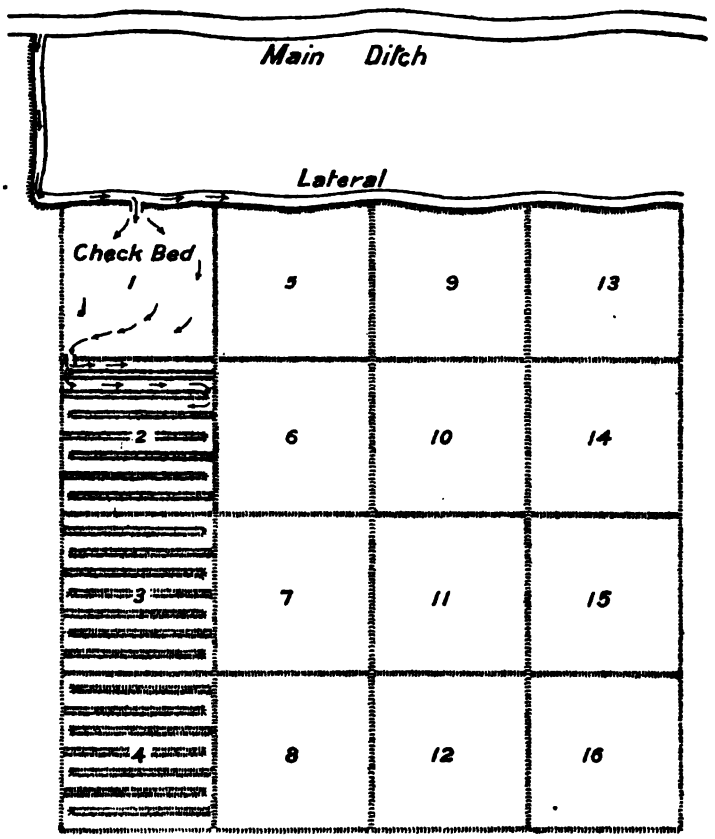

FIG. 4.—Diagram illustrating method of flooding in checks.

flooded, the border at a point at the end of this bed is broken down and the water allowed to flow into the second bed, and so on until the whole field has been flooded. Of course a series of these beds may be irrigated at the same time, the number depending upon the flow of water. The accompanying diagram, fig. 4, shows the system. Beds numbered 1, 5, 9, and 13 may all be irrigated simultaneously, and as they are finished those adjoining are flooded.

This is the system invariably practiced by the Mexicans, but it has the disadvantage of letting the water drain off from the upper beds

onto the lowest one when the water is shut off, thus giving an undue proportion of water to the end bed. A better plan, and one adopted by some of the more observant farmers, is to open up all the checks and let the water run unobstructed to the end; then, when the water has covered the lowest square or bed about 3 inches deep, it is shut off from that bed and the next above is filled, and so on back to the head of the land. By this method it is claimed that the land is watered more uniformly.

This system of flooding and level culture is practiced for all small grain crops, beans, orchards, and alfalfa, but for the latter crop the borders are made lower and broader, so as not to interfere with the mower and rake, and the land must be very carefully graded before the alfalfa is sown.

For crops cultivated on ridges, such as tomatoes, chili, sweet potatoes, etc., a modification is introduced. Ridges are made in the check beds, as shown in beds 2, 3, and 4 of the diagram, the ridges being shaded in the diagram and the furrows running between. The water is let in at the corner of the bed and allowed to run until the furrows between the ridges are filled, when it is let into the next bed and the same operation is repeated.

FURROW IRRIGATION.

So far what is known as the flooding system of irrigation has been described, and this has proved to be the only practical way of irrigating many crops, such as small grains, alfalfa, etc. But for orchards the furrow system has been recommended, owing to its successful and almost universal adoption throughout California. This system consists in opening up a number of small furrows by means of an ordinary or double-moldboard plow between the rows of trees. The water is then allowed to run slowly down these furrows from one end of the field to the other until the land is perfectly saturated, the time occupied often being twelve hours.

The advantage of the furrow system is that the water is thereby prevented from coming in contact with the trunks of the trees, a contact which is often harmful, causing sun scald. The land is also more easily cultivated and the surface reduced to a finer tilth after such irrigation, for, not being all wet at the top, it is mostly left in a friable condition after the furrows dry out, whereas by the flooding system all the surface soil gets compact and hard, rendering subsequent cultivation somewhat difficult. Some three or four years ago the furrow system was much talked of and was actually tested at the experiment station, but, whether from the insufficient amount of water applied or the innate defects of the system, the results were not satisfactory, and the most intelligent farmers condemned the furrow system of irrigation as being impracticable on this soil.

Theoretically the furrow system is perfect, and it certainly gives satis-

IRRIGATED FARM IN THE MESILLA VALLEY.

factory results in California, where doubtless the soil is more porous than in the Mesilla Valley and the water is of a different character. After much personal observation I am inclined to believe that it is unsuited to the circumstances existing in this valley. In the first place, the soil is of such a nonporous character that there is little or no lateral seepage, and it may be frequently noticed that one portion of a field will be completely saturated with water, while the soil at a distance of only a few feet remains perfectly dry. In the second place, the river water is exceptionally muddy, and, if run in a furrow for any considerable length of time, deposits a sediment which makes the furrow almost water-tight and incapable of absorbing the water in sufficient quantity to saturate the adjoining soil. Almost all the practical orchardists and farmers have come to the conclusion that the flooding system is the only effective method of thoroughly saturating the soil, and this opinion is shared by the intelligent German truck gardeners around Albuquerque, a city farther up the river, who, as the writer found on a recent visit there, are all using the flooding system. As regards the danger of letting the water come in contact with the trunks of the trees, this is and should be obviated by planting the trees on the borders of the check beds or by a slight mound of earth around each tree.

QUANTITY OF WATER NEEDED.

The amount of water needed for irrigation in the Mesilla Valley will naturally vary with the different crops, but as there is no system of measurement adopted it is impossible to fix this in feet or inches. In actual practice the intelligent farmer irrigates as often as in his opinion the crop seems to need water, always bearing in mind that for fruit trees and deeply rooted plants no water is needed so long as the soil at the depth of 4 or 5 inches is sufficiently moist to roll up into a ball, whether the land was irrigated a week or a year ago.

How much water is used or needed at each irrigation is an open question, as no tests have ever been made in the valley. It may, however, be said that a great deal more water is needed in this arid climate than is generally supposed and often recommended by irrigation engineers, who seem in their writings to try to break the record by fixing the amount of water at the very lowest limit, so that one frequently reads of 12 inches per year being sufficient for orchards and most other crops, while 24 inches is looked upon as more than a liberal allowance. Now, if by 12 or even 24 inches in the year is meant 3 or 6 inches in any given three months I have no hesitation in saying that in this soil and dry climate either quantity would prove utterly inadequate. Practical men with whom I have discussed the subject are of the opinion that not less than 4 inches, and often 6 inches, of water will be profitably absorbed by the soil at each irrigation. I recently made the experiment of irrigating a field of strawberries from a reservoir holding 55,000

gallons, and although the soil was by no means dry, being fairly moist at the depth of 4 or 5 inches and the plants had not yet suffered from drought, I found that this amount of water, used sparingly, was surely sufficient to irrigate four-sevenths of an acre. This means that the land had all been covered with water to the depth of 3½ inches, and seems to show that not less than 4 and probably 5 inches of water is profitably used at each irrigation. As orchards and many other crops will need 4 and often 6 irrigations during the three months beginning in April or May, it follows that from 20 to 30 inches may be considered a fair allowance for the three months, and an average of probably 40 inches during the year.

I am aware that, according to many authorities on irrigation, this quantity will appear excessive, but, in considering the amount of water needed in this valley, one must not overlook the fact that the atmosphere here is one of the driest in the world and that evaporation is consequently very rapid. Tests made at El Paso[1] show that the amount of water evaporated in an open pan in some of the dry months was over 11 inches, and that a total of 95 inches has been reached during a year. A great part of the water used in irrigation is transpired by the leaves of the plants, and although no comparative tests have ever been made, the transpiration is doubtless much greater in a dry climate than in a humid one. These facts account for the large amount of water which appears to be needed and profitably used in this valley.

Taking some of the principal crops, I find that the number of irrigations given is as follows: A peach or apple orchard will need one irrigation at the beginning of winter, another early in the year, and four or five from April to August. Wheat land is usually irrigated before the seed is plowed in, then again after seeding, and five times subsequently. If the wheat is sown early, say by November 1, it may be followed the same year with corn, which receives six irrigations. Land thus cropped will take a depth of from 55 to 60 inches of water during the year, and a vegetable garden will certainly need quite as much. Vineyards usually receive five irrigations in the course of the twelve months. Alfalfa will drink more water than almost any other crop. It is usual to give it a good soaking early in winter, another at the end of March, and one every fifteen days from May 15 to August 31, and a final one in September, or, say, ten irrigations during the year.

Taking the average of these crops, which are the principal ones raised in the valley, we find that, allowing 4½ inches to each irrigation, the land receives during the year sufficient water to cover it to a depth of 44 inches, and many farmers undoubtedly use a great deal more, although the more intelligent consider the quantities mentioned as sufficient.

In November, 1893, an experiment was commenced at the college farm in order to see if by means of frequent cultivation a much less quantity of water than the above could not suffice. The peach orchard

[1] Fourteenth Ann. Rept. U. S. Geol. Survey, Part II, 1894, p. 154.

was irrigated in November and again in March, receiving a good cultivation every fortnight during summer. The result was that, although the fruit might have passed muster in some districts, it was so inferior to the peaches raised in the orchards that were irrigated during the winter, and which received copious supplies of water every eight or ten days from the time the fruit set until it was gathered, that I should have unhesitatingly condemned it all as unmarketable had it been offered to me for sale, for it was small, dry, and "runty." Moreover, by July the trees began to shed their leaves, and showed unmistakable signs of sickness. On the whole, it seems to be somewhat difficult to apply too much water, provided always that each irrigation be followed by a complete cultivation of the surface soil.

CULTIVATION AFTER IRRIGATION.

Although much has been learned from the native Mexicans in the art of farming under irrigation there is one fact which they do not seem to appreciate, and that is the absolute necessity of cultivating the soil after each irrigation as soon as it is dry enough to work. The Mexican knows that cultivation is needed to keep down the weeds, but this seems to be the limit of his knowledge. He is evidently unaware of the fact that the roots of the plant need air quite as much as water, and that the muddy water plasters down the surface to such an extent that unless it be broken and pulverized after each irrigation the air is practically shut off from the roots of the plant.

The killing of weeds and the aeration of the soil are not the only benefits accruing from cultivation. The pulverization of the surface soil by means of cultivation helps to retain the moisture in the soil below. At first sight it usually appears to have the opposite effect, for after the soil is pulverized it dries very rapidly. Last summer I set a Mexican to work with a wheel hoe to cultivate strawberries. After doing about half an acre he remarked to me in his native language, "Patron, it seems to me that the stirring of the soil will make it dry out much faster than if left alone." "I don't think so, José," I replied. "You hoe your chili after each irrigation. Why do you do it?" "Because it won't grow unless we keep the soil around continually hoed," he explained. "Yes," I replied; "it is because the loosening of the top soil preserves the moisture below and lets in the air to the roots." Nine days later I took my Mexican to a patch of ground that had been left unhoed, and he was obliged to admit that at a depth of 3 inches it was much drier than the land he had hoed, and when he again cultivated the soil he had the satisfaction of feeling that it was not labor lost.

That cultivation of the upper crust of the soil tends to prevent evaporation of the moisture below is a fact known to every practical farmer. It is daily being proved in actual practice, but the scientific theory upon which this practice is based is little understood. Men will tell you it is so, but why they do not understand.

Even scientific writers have been satisfied by stating that water rises in the soil by capillary attraction, as oil rises in the wick of a lamp, and that, by cultivating the surface soil, one breaks up the capillarity and so prevents evaporation, or that the fine tilth on the surface acts as a blanket in retaining the moisture. It is only quite recently that a more perfect explanation has been given.

When the soil is dry each little particle is surrounded by an air space. Whenever the particles come in contact with moisture they have the power of attracting that moisture and of surrounding themselves with a thin film of water. The particles next to the water first draw the water around themselves, then the dry particles next to them in turn attract it, and so a continuous stream is set up, much in the same way that a wick of a lamp draws up the oil. This goes on until the whole body of soil is saturated, but as soon as the water reaches the particles on the surface of the soil this water is evaporated, and the supply below is again drawn upon, until the water stored below is so exhausted, or left at such a depth, that the distance overcomes the power of attraction and the soil becomes completely dry. This is the process which goes on in uncultivated soil.

The object of cultivation is to break up this attraction, usually called capillary attraction, in the upper crust, and so prevent the moisture from being brought to the surface and evaporated. To understand how this is done, one must take into account another fact, viz, that if these little particles in the soil be widely separated from one another they lose their power of attraction. Now, when the top crust of the soil is loosened and reduced to a fine tilth, these particles lie less closely together and do not attract moisture from below. The moisture now rises as high as the upper tilth, and there remains much longer than in the case of untilled soil, for, owing to the blanket or mulch of loose soil on the top, the soil below the surface is much less exposed to the action of evaporation.

Some of our farmers are unwilling to accept this theory, alleging that adobe or clay soil, that has never been cultivated for years, will have more moisture below than cultivated soil. If this be so, the fact does not clash with the theory of particle attraction. On such soil the top surface has been packed down so closely that the surface is practically puddled, in which case the attractive power of the particles is destroyed. It is the same as though the surface were covered with a large rock or a board, and the evaporation thereby suspended.

WINTER IRRIGATION.

When I first came to New Mexico, in 1890, I found that the prevailing practice with orchardists was to withhold water from the trees during September and October, in order to let the young wood ripen, then give one irrigation in November, and not apply water again until the peach buds had come into blossom. The reasons alleged for this method of

treatment were that the trees did not need water during the winter months when they were dormant, and that by keeping off the water the fruit buds were retarded.

It is needless to say that no objection can be raised against withholding the water while the young wood is ripening, but that by keeping water from the trees in the spring the blossoms are held back has been shown to be a fallacious idea. The fact is that the bursting of the bud is entirely dependent upon the state of the outside and surrounding atmosphere, and if the application of water to the roots has any effect whatever upon the buds, the evidence is in favor of the theory that it retards rather than hastens the blossoming period.

It would appear that this mistaken notion about trees needing no artificial irrigation during the winter has arisen from two sources: (1) There is a popular delusion that the tree is dormant during winter. Any one who has heeled in young trees in the fall and lifted them again in spring can not have failed to notice that the roots have made growth during the interval. Moreover, by careful measurements made at the experiment station here it has been proved that even the trunks of the trees, and doubtless also the branches, actually increase in girth during the winter months. It is therefore evident that the tree is in active growth during the winter and is laying up a store of energy for the coming summer. If the tree during that period suffers from drought its vitality must be weakened. (2) The people here have been told that in California it is not customary to irrigate orchards during the winter. They, however, have not taken into consideration the fact that heavy rains fall during the winter over the greater part of the Pacific Coast, whereas in the region of the Rocky Mountains the winter months are the dry season. Furthermore, if we look at those countries where fruit grows to the greatest perfection without irrigation, we see that they have their principal rainfall during the winter. I need only to refer to the south of France, where nature gives us a valuable lesson on the application of water to fruit trees during winter.

I know of two large peach orchards on similar land and within a quarter of a mile of each other, one of which was not irrigated during the winter, while the other received three or four copious irrigations. The peach blossoms opened a few days later in the irrigated orchard, but its fruit ripened at least a week ahead of that in the other orchard. I am inclined to think that the moisture of the soil tended to keep the air around the irrigated trees cool and so retarded the blossoms, but when the fruit on these trees started to grow it rapidly overtook that on the others, which, owing to a lack of moisture, were deficient in vitality, whereas the irrigated trees were in a condition to devote all their energies to the development of the fruit.

In the valley it has also been customary to hill up the vines with earth in November and to apply the water during the winter. It is not the cold that is feared so much as the dry winds in the early months of

the year, and if the trunk of the vine is not protected it is apt to crack and the buds to winter-kill. An American orchardist in the valley, who has made the experiment for two years, assures me that if the vines are irrigated during the winter they go through with perfect safety and without any necessity of hilling up. It would certainly seem that there is as good reason for irrigating vines in winter as there is for irrigating fruit trees.

There is another good reason why orchards and vineyards should be irrigated in winter. The work can be done when the farmer is not otherwise busy and when water is invariably plentiful. Water which would otherwise be wasted is saved by thoroughly soaking the ground down to a good depth; then, should there be a short supply of water during the summer, the trees are able by capillary attraction to draw upon the reserve water stored during the winter and thus better to withstand drought.

GARDEN IRRIGATION.

Hitherto only the methods applicable to field culture have been referred to. For vegetable-garden culture a more perfect and less slovenly system is desirable, and the following plan has been found to be the most satisfactory:

In the first place, the main irrigating ditch must run along the highest side of the garden. Let us imagine that it runs along the northern boundary, as shown in the accompanying diagram (fig. 5). The entire garden is then laid out in oblong beds, usually about 20 feet long and 12 feet wide, with the narrow sides east and west. This is a convenient size, but they may be a little shorter, so as to fit the space it is intended to cultivate, or where vegetables are grown on a large scale the beds may be made somewhat larger.

Each bed is surrounded by a border raised about 1 foot and about 2½ feet broad at the base, and these borders serve both as paths and to retain the water. Each bed must be perfectly level, although of course one may be higher or lower than its neighbor.

Throughout the length of the garden and running north and south one or more lateral ditches are constructed, which should be about 2 feet wide, with the bottom rather higher than the level of the beds. These laterals are so arranged as to have one row of beds on each side, as it is from these laterals that the beds will be irrigated. To make the plan clear, I have spoken of the construction of the beds before that of the laterals, but in actual practice the laterals are more easily made first.

For each bed there is now made, with 1-inch lumber, a small box 4 inches square inside and 3 feet long, with a sluice gate at one end. By a sluice gate I mean a little trapdoor that slides up to let the water pass or is put down to shut it off, as shown in fig. 3. These boxes are placed in the bank of the lateral, so that the bottom of the gate end is

on a level with the bottom of the ditch. The boxes are then covered with earth, which is pounded around them, so that the water will not cut through along the bottoms or sides. The boxes are placed opposite each other, so as to let the water in to the center of each bed. In the laterals, and just below each pair of boxes, it may be necessary, if the fall is great, to make small checks or dams with a piece of lumber, 6 inches high, so as to bank up the water and throw it into the little boxes.

When it is required to irrigate the garden, or any portion of it, the

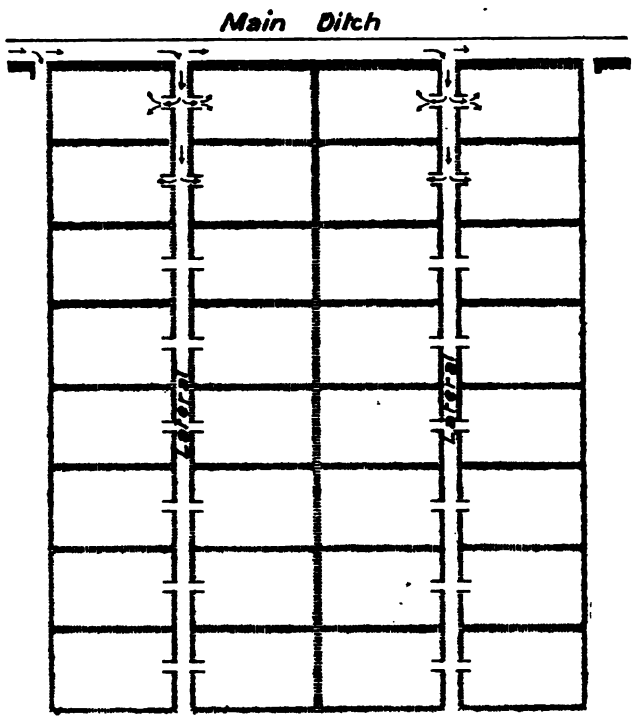

FIG. 5.—Plan of an irrigated garden of one-half acre.

water is let in slowly from the main ditch and allowed to flow down the laterals. As it comes to the box of each bed the little gates are opened and the water allowed to flow gently over each bed. A number of beds may be irrigated at one time, the number depending upon the head of water. Care is taken not to have such a head of water as will wash the soil, and not to let it stand too long or too high in the beds, so as to drown the plants. As soon as sufficient water has been applied to any bed the water is shut off by the sluice gate and another opened, until the entire garden has been irrigated.

This method has many advantages over the slipshod custom of tearing away openings in the banks of the laterals and then building them up again as each bed is irrigated. In the first place, the flow of water

is better regulated and only enough is admitted to each bed to do the work slowly and surely, sufficient time being taken to allow it to soak well into the soil. The scouring and washing away of the earth, whereby small plants are frequently smothered by the old method, is also avoided. And finally, the whole operation can be performed with the minimum exertion.

Although the plan sketched is especially applicable to small gardens cultivated with the spade, it will be seen that there is nothing to prevent the use of a horse plow after the crops are gathered, as the entire length of the garden may be plowed up, leaving only the laterals intact. The same plan may be modified to suit a small orchard, where vegetables are to be grown between the trees. The beds may then be made 24 by 12 feet and the trees planted on the borders, as shown in the diagram, so that they stand 24 feet apart each way.

Almost all the gardeners here are of opinion that the best time to irrigate vegetables, and indeed all crops, is in the evening, just as the sun is going down, as the hot sun shining on the wet foliage is apt to injure or even kill the plants. Irrigation by moonlight is still better, and some think that very early in the morning, before the sun is up, is a good time.

After each irrigation the surface soil must be stirred with a hoe as soon as the land is sufficiently dry. The better and more economical plan is to use a wheel hoe. It is quicker and does better work than a hand hoe, and can be set to plow, cultivate, or weed between the rows of plants.

The question as to whether the water should be applied to the beds by the flooding or furrow system depends upon the variety of vegetable cultivated. Many crops, such as potates, chili (red pepper), tomatoes, melons, etc., need to be grown on ridges, with irrigating furrow between, and the beds as planned can be utilized for either system.

Vegetables are irrigated as often as the plants show signs of flagging, the usual intervals ranging from ten to fifteen days during the growing season. Large plants will not need water whenever the soil at a depth of 5 inches is moist enough to roll up into a ball; but for small seedlings or newly transplanted vegetables the surface soil must never be allowed to become very dry.

PUMPING WATER FOR IRRIGATION.

WINDMILLS.

Pumping water for irrigation has been resorted to in but few cases, either in this or the other valleys along the Rio Grande, although abundant water can be obtained almost everywhere at depths varying from 14 to 85 feet, this depth depending upon the height of the land above the level of the river bed.

In the Socorro Valley, situated on the Rio Grande 134 miles north of Mesilla, and where the surrounding circumstances are very similar to

those here, Mr. C. T. Brown has erected a windmill, pump, and reservoir on the mesa above the valley. The well was sunk 85 feet deep, lined with stone and cement, and cost $350. The windmill, with a 12-foot wheel, which had cost $125, worked with a 4-inch cylinder and a 2-inch pipe, although Mr. Brown advised using a 4½-inch cylinder and a 3-inch pipe where the water was nearer the surface. The reservoir, built of rock and cement, is 27 feet long by 17 feet broad and 5½ feet deep, and is capable of holding over 20,000 gallons. Its cost was $300, making the total outlay $800.

The water is very soft, without a particle of alkali, and for over two years Mr. Brown has successfully irrigated 2 acres of trees and vegetable garden. The windmill fills the reservoir on the average three times a week, at which rate there would be water enough to give an irrigation of 4½ inches of water every fourteen days to about 1 acre of land.

At Las Cruces I have a windmill with an 8-foot wheel, lifting the water 21 feet, the water stratum being only 15 feet below the surface. The cost of erecting this windmill and pump was $200, and the reservoir, built of earth and capable of holding about 55,000 gallons, will have cost nearly $180 by the time the interior is cemented, which I find it will be necessary to do. The windmill has not been running long enough to enable an accurate estimate of its capacity, but, so far as I can see, it will take an average of fifteen days to fill the reservoir, and I find by actual practice that this amount of water will irrigate only about half an acre of land. It is possible that the pump would work faster if there were a sunken well instead of a driven point, but the quicksands make a sunken well too expensive. By adding a second windmill and pump I should, at a total cost of $580, have enough water to irrigate 1 acre of vegetable garden.

It will, then, readily be seen that so long as one can get water from the river at a cost of 50 to 75 cents per acre per annum and the best land in any situation at not exceeding $100 an acre, including a perpetual water right, windmill irrigation can hardly be a financial success, owing to the great initial outlay, although it might pay under some exceptional circumstances.

STEAM PUMPS.

At the Shalem colony, a religious community in the Mesilla Valley, a very extensive experiment has been made in pumping water by steam power. An open well 18 feet in diameter, lined with stone and cement, has been sunk to a depth of 33 feet. At the bottom of this well are sunk one 6-inch casing and two 6-inch standards, going 30 feet below the bottom of the well and coupled 2 feet above. There are also an 11⅝-inch casing 30 feet deep and a 6-inch standard 200 feet deep, but there is very little flow through these latter. The well fills up to within 12 feet of the top, or say 21 feet of water, and three hours after

starting to pump only 6 feet of water is left in the well. After this the flow of water is equal to the full capacity of the pump, the suction of which is 12 inches and the discharge 10 inches.

The proprietor says that this supply of water seems to be entirely independent of the river, the water flowing into the well the same when the river is empty as when it is full. The water appears to come down the valley from the north, and therefore pipes should be sunk in a line east and west. The three 6-inch pipes are so situated, but the 11⅝-inch pipe is about 5 feet south of them, and when the former are uncapped but little comes through the 11⅝-inch pipe. the 6-inch pipes giving vent to nearly all the water.

The water is raised by a 60-horsepower boiler, with a pump capable of lifting 1,000 to 1,200 gallons per minute. The reservoir is built of light soil, lined with a coating of tar and gravel and then covered with pitch. It leaked a little in one place at first, but none since. The area of the reservoir is 1 acre and the depth of water 5 feet, although the total height of the walls is 6½ feet. With the pump running continuously it can be filled in thirty hours, at a cost of $18 for fuel, labor, etc.

Presuming that it filled ten times in fifteen days, there would be sufficient water to give an irrigation of 4½ inches every fifteen days to 146 acres; and this amount of water would not, I think, be more than sufficient for most crops, although 175 acres, mostly in orchard, are irrigated (inadequately, it is said by observers) by pumping only a part of the time in summer.

The estimated cost of such a plant complete is about $15,000, which would bring up the initial cost to $100 per acre, or only about one-seventh that of windmill irrigation. Allowing for eight irrigations in the year and 10 per cent on the capital invested, and including fuel and labor, the cost of irrigation per acre amounts to $20.05 per annum. Even at this cost the proprietor considers the work satisfactory, as he is insured a certain supply of water throughout the year.

There is another drawback to irrigating with well water as compared with using the river water, and that is, that the land does not receive the annual fertilizing which it does from the sediment of the river water. It is even said that the well water, being slightly alkaline, will ultimately prove injurious to vegetation. Doubtless the water from some of the strata is too highly charged with alkali to be safely used, but by exercising a certain amount of judgment in selecting the depth from which the water is drawn this difficulty can be overcome to a very great extent. It has been asserted that the quality of the water improves after a well has been used for some time, the alkaline salts being exhausted or washed out.

On the whole, it appears to the writer that the experiments so far made tend to prove that, if the river water be properly stored and distributed, the pumping of water, either by steam or by windmill power, is not needed in the valley.

RESERVOIR AT SHALEM COLONY.

SOIL OF MESILLA VALLEY.

The greater part of the soil consists of a gray clay, called adobe, the result of the disintegration of the solid rocks. It has been washed down from the highlands into the valley, or brought by the river and deposited along its banks. There is also a considerable amount of sandy loam, sometimes on the surface and at other times underlying the top stratum of adobe. This sandy loam and adobe often lie upon sand, which is found at depths varying from 3 to 10 feet.

Here and there are also patches of bare sand, upon which it would appear quite impossible to raise anything. However, if the sand be leveled and the river water from the irrigating canals be allowed to run over it for a year or two, it soon becomes fertile, and the longer crops are raised upon it the more its fertility increases. This is due to the sediment deposited by the river water, which contains a large proportion of fertilizing ingredients.

Forty-eight inches of river water will deposit half an inch of sediment, so that in the course of twelve years the sand will be covered with 6 inches of rich soil, and if this be mixed with the sand by plowing, one gets a foot of magnificent soil where before there was a barren waste. Much of the soil has been formed in this way, some artificially and some by the natural overflow of the river in past ages.

ALKALI.

Throughout the Mesilla Valley, and indeed all along the Rio Grande, alkaline spots occur, shown by the white crust upon the surface of the soil. The principal salts composing alkali are known by the names of Glauber's salts, common salt, sal soda, and saltpeter, with a mixture of carbonate of lime and sulphate of potassium. Where sal soda or sodium carbonate predominates the mixture is known as black alkali. It then appears on the surface as a black puddle. This is the worst form of alkali and the most harmful to plant life. It is seldom seen in this valley, however, owing to the fact that the water used for irrigation contains a sufficient proportion of gypsum to convert black alkali into white alkali. It is therefore only with the latter that we have to deal.

It should be understood at the outset that most of the ingredients found in alkali are necessary for plant life—especially potash and carbonate of soda, which are really important fertilizers and which become injurious only when present in excess. Hence alkali is not a sign of poor soil, but rather the contrary.

The harm is mostly done by the accumulation of the alkali on the upper crust of the soil, where, by its caustic properties, it injures the stems of the plants with which it comes in contact. How this injurious accumulation takes place is thus explained: Most of the salts contained in the alkali are soluble in water, and are consequently dissolved

when water is applied to the land either artificially or in the form of rain. When the water so applied is again brought to the surface by means of capillary attraction, and evaporated, the alkali remains on the surface. By repeating this process the salts for some depth are all brought to the topsoil. It has been ascertained that there is often six or seven times as much alkali in the first inch of soil as in the next foot.

There are two methods of treating white alkali: The first gets rid of it altogether; the second overcomes its injurious effects. We will take the latter method first, because it is the easier and the one usually practiced in the valley with success.

It has already been shown that the injury is caused by the accumulation of the alkali on the surface. The remedy is deep tillage, so as to mix it up with the top 8 or 10 inches of soil, and then, by means of good cultivation, to keep it from accumulating at the surface. If the surface of the soil is stirred after each irrigation, as it should be whether there be alkali or not, the water can not come to the surface, and without the water the alkali can not get there either. All the native Mexicans say that they have no difficulty with alkali when the land is well cultivated. Alfalfa also seems to keep down the alkali, probably owing to its shading the land and thus preventing the water from evaporating at the surface.

The Mexicans have an idea that the application of barnyard manure also dispels the alkali, but it is difficult to account for this, except on the theory that when a man takes the trouble to apply barnyard manure he also gives perfect tillage and cultivation.

It is doubtful if there is any considerable extent of alkali land in the valley that can not be successfully treated in this way, but where such an excess of alkali exists as to render its absolute removal necessary the only remedy that has been suggested is to underdrain the land with pipes, and then flood the land so that the water will flow through the drain pipes and carry the alkali with it in solution. It would be useless to attempt to carry off the alkali by flooding on the surface and letting the water run off the land; the alkali would dissolve and sink down immediately the first water touched it. Not only would artificial drainage be very expensive, but it would generally be difficult to find a fall or outlet for the drainage water.

It is asserted that crops of beets, which are known to be alkali feeders, will effectually remove white alkali, but this remedy has not been tried in this valley, nor, indeed, has it been considered necessary. The opinion is also held that when the land is heavily flooded by irrigation, as is the Mexican custom, the water carries down the alkali to such a depth that it is carried away by the natural underdrainage of the valley. It is possible that this may account for the fact that the longer land is under cultivation in the valley the less alkali appears on the surface.

BUILDINGS ON A FRUIT FARM.

NECESSITY OF FERTILIZATION.

After being assured that a great surplus of fertilizing ingredients is yearly deposited on the land by the irrigation waters, the reader might conclude that the application of barnyard manure in the Mesilla Valley would be quite superfluous. It has, however, been conclusively proved in practice that even in the case of wheat, which removes only half the nitrogen yearly deposited by the river, the crop is very considerably increased when the land receives a moderate dressing of barnyard manure every three or four years, while it is impossible to successfully raise vegetables unless barnyard manure is freely used.

It is claimed by some that these good effects are due to the improved mechanical condition of the soil and its increased power of holding moisture, and doubtless these facts may have something to do with the result, but it is probable that the real explanation is to be found in the action of "soil ferments." Nitrogen may exist in the soil even in excess and yet not be in a form available for plants to feed upon, and the same may be said of other fertilizers. It has been demonstrated that nitrogen in the soil is reduced to nitric acid by means of living bacteria, which are multiplied by fermentation, and this fermentation occurs most rapidly in decomposing barnyard manure. How bacteria perform this useful work is not fully understood, but it has long been noticed, not only in this valley, but elsewhere, that a dressing of barnyard manure produces fertilizing results far in excess of what could be expected from the quantity of plant food contained therein. Chemical analysis often discovers quantities of plant food in the soil which seem amply sufficient to produce remunerative crops, and yet the soil is practically poor. It would thus seem that nitrogen may exist in the soil in an inert form in large quantities and not be available for plant food until subject to the decomposing effects of bacteria.

It has also been found that these bacteria multiply and work most actively quite near the surface of the soil. This accounts for what has frequently been experienced in the Mesilla Valley, and probably in other irrigation districts, where it has been necessary to scrape off the surface of the soil in order to make it level enough to irrigate, namely, that land so scraped remained comparatively infertile for a number of years.[1]

NATIVE FARMERS AND IRRIGATORS.

In order to obtain a true conception of the methods of irrigation practiced in New Mexico and adjacent portions of Texas, it is essential to know something of the native farmers and laborers. All agricultural practice must, to a certain extent, be governed by the efficiency and cost of labor and by the skill and habits of the laborer. Primitive

[1] Soil ferments important in agriculture, by H. W. Wiley: Yearbook of the Department of Agriculture for 1895, pp. 69-102.

methods have usually been developed through centuries of experience, and while they may not always be desirable, yet much may be learned by observing the customs of the natives and by ascertaining the origin of these.

Almost all the irrigation and cultivation in New Mexico is performed by native Mexicans. As farm hands, especially in an irrigating country, it is doubtful if they can be surpassed at the price, which is 75 cents a day without board. The writer has always found them to be intelligent and industrious workers, willing, obliging, and civil. Moreover, they are sober and never strike.

Although on their own farms their implements are usually of a very primitive description, this is not due to any lack of an intelligent desire for better things or any unwillingness to adopt modern tools and machinery, but rather to lack of means to make the necessary outlay. In the neighboring valleys of Loma Parda, Colorado, etc., harvesters and threshing machines have quite recently been introduced with great success, the native Mericans being quick to appreciate their advantages. It is also within my experience that hay balers which had been discarded by Americans on account of continual breakages were taken by Mexicans and operated with complete success.

Much of the land in the valley is let on shares, the tenant doing all the work on the irrigating ditches and delivering to the proprietor at his residence one-fourth of the produce. This for unimproved land. In the case of improved land or orchards and vineyards, the share paid is higher, being often one-half. In all cases within my experience the tenants have faithfully performed their contracts, which are in most cases merely verbal. Indeed, it is well known by the older residents that a Mexican's word is as good as his bond, and that except for the purpose of avoiding any misunderstanding written contracts are superfluous. It may be of interest to note that many of the best and most reliable Mexicans are those who can not read or write. Education has not raised the standard of morality. It is the fashion to depreciate the Mexican and talk of him as lazy and unprogressive, and especially is this the case with those least acquainted with these people. This impression of laziness is partly due to the fact that in this sunny climate the idle men are seen out of doors, whereas in colder countries they are indoors and unseen. On the whole it may be said that the native Mexicans compare favorably with members of any other nationality in the same social scale. They are patient, polite, and law-abiding, and it is perfectly safe to travel among them unarmed, either by day or by night.

All the Mexican houses are built of what are called *adobes*—that is, sun-dried bricks. These bricks are usually 18 inches long, 9 inches wide, and 4 inches thick. They are laid in mud, and usually cost, laid in the wall, $15 per 1,000. Many of the walls are 3 feet thick, but 18 inches is quite sufficient for a one-story building, and no Mexican

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house is more than one-story high. The thick adobe walls are quite impervious to heat and cold, so that the houses are warm in winter and cool in summer. They are, therefore, admirably adapted to the climate, and are preferable to houses built of brick or wood.

The roofs are made of the same material, that is, adobe mud, laid over heavy beams covered with brush or rushes. They are, however, a constant source of anxiety, being very apt to leak unless well attended to. A much better covering is a light adobe-mud roof and over this, with an air space between, a corrugated-iron roof. This is quite as cool as the adobe roof, as the mud under the corrugated iron prevents the passage of heat, and the iron roof is always water-tight.

These adobe houses are much more durable than they appear to be. Many adobe buildings exist which are known to have stood two centuries or longer. As every Mexican knows how to make and lay adobes, the building of an adobe house entails no cash outlay, except for doors and windows. The consequence is that the houses of the very poor consist of one or two rooms, often with no windows and with but one door to the house. Very elaborate and comfortable houses can, however, be constructed with these adobe bricks, especially when they are plastered and painted on the outside. The usual plan of architecture is to build the various rooms around an open courtyard or *patio*.

IRRIGATION AND CULTIVATION OF VARIOUS CROPS.

In the following pages the methods of applying water and of cultivating the various crops, such as wheat, corn, and alfalfa, will be briefly described, and reference will be made to the agricultural practice in regard to gardens, orchards, and vineyards. Considerable space is given to the description of customary methods, in order to bring out more clearly the best means of utilizing the water resources and to illustrate the writer's ideas as to what should be accomplished.

An explanation may be given here for abstaining from the publication of many figures showing the prices of farm produce in the Mesilla Valley and the quantities raised per acre. In the first place, prices may be very different a few years hence, and to give those of to-day would therefore probably be misleading. In the second place, statements of prices and yield per acre have generally been exaggerated, and the author of this paper is not desirous of laying himself open to criticism. It is sufficient to say that the quantity of irrigable land in New Mexico is so small compared with the necessities of the mining and other industries that doubtless for very many years, and perhaps for all time, the prices of farm products are likely to be as high as those in the more eastern States, plus the cost of freight.

WHEAT.

Anyone conversant with the methods of raising wheat in vogue a thousand years before the Christian era will be able to form a conception of the manner in which the native Mexicans carry on their work

at the present day. The first operation is to collect and burn the forest of weeds, often higher than a man's head, which have accumulated during the preceding summer. Then "the sower goeth forth to sow," which he does by carrying the wheat in a tin pail and scattering it broadcast with his hand. The plows follow, mostly drawn by one small Mexican pony. The surface soil is slightly stirred to the depth of about 3 inches and the seed is thus covered.

This done, square beds are made all over the field and surrounded by high borders to contain the water, these being made by the plow and finished off with a heavy hoe. If the land is not sufficiently moist to sprout the seed, water is now applied with reckless extravagance. As fast as the surface soil dries out, more applications of water are made, usually about five in number. There is no manuring of the soil, no weeding, and no cultivation. Until the crop ripens the Mexican squats in the sun on his haunches and watches the work of nature; or if the sun is too hot he sits under the shade of his own vine and fig tree.

Early in June he and his sons, cousins, and nephews arm themselves with primitive iron sickles and proceed to cut down the crop. Most of the straw is left standing, for the Mexican has no use for straw. Then to the thrashing floor, which is merely beaten mud. Here the observer would imagine himself somewhere on the outskirts of Jerusalem in the days of Naomi, especially if his acquaintance with the Spanish dialect is not sufficient to enable him to distinguish it from Hebrew. A herd of goats or sheep, and sometimes ponies, is now brought onto the scene, and amidst much shouting and cracking of whips the animals are made to run round and round the thrashing floor until the grain is parted from the husks. This is an exact repetition of the ancient "treading of the corn." This done, the short straw is raked off, leaving a pile of wheat and chaff. Then follows the ancient process of winnowing, practiced thousands of years ago. With broad shovels the grain is tossed into the air, that the wind may blow away the chaff. Of course rain sometimes interferes with these primitive and tedious operations, but no misfortune can depress the spirits of these workers.

CORN.

Next to wheat, corn is the most important grain crop raised in the Mesilla Valley. The usual method pursued is to open a small furrow with a plow and then to drop in the seed by hand, at intervals. As soon as the plant is sufficiently high, the rows are hilled, and during the season about six irrigations are given, although the crop will mature with much less. The furrows are also cultivated after each irrigation, or at least they should be.

The corn is usually sown some time in May, and land is mostly cropped with wheat one year and corn the next, although if the wheat is sown and harvested early a crop of corn or beans may follow the

CONTRA-ACEQUIA AND LATERAL IN MESILLA VALLEY.

same year. As a rule, however, the wheat is sown too late, often far into December. Much better crops of wheat would be raised if it were always in the ground by the 1st of November.

ALFALFA.

Alfalfa is a perennial plant, and when once sown will last for many years. It is difficult to say how long it is profitable to keep the same field in alfalfa, but there are many instances of land that has borne crops of alfalfa for twenty years, and even for a longer period, without showing any signs of depreciation.

The seed is usually sown in February, on land already seeded to wheat, and oats are also frequently sown with the alfalfa in order to act as a shade to the young plants. But quite as good results have been obtained by sowing the alfalfa alone. The seed may also be put in the ground at the end of September. The young plants will soon appear above the ground and will continue to grow, in roots if not in leaf, during the greater part of the winter.

The cost of seeding an acre of land in the Mesilla Valley with alfalfa is as follows:

Plowing and harrowing	$5.00
Drilling seed	1.25
Making borders for irrigation	2.50
25 pounds of seed, at 8 cents	2.00
Total	10.75

The annual expense will be:

Cutting, raking, gathering, and stacking 3½ tons, at $1	$3.50
Irrigating six times, at 15 cents	.90
Water per acre	.75
Cleaning lateral ditches	.50
Baling 3½ tons, at $1.35	4.72
Hauling to railroad 3½ tons	3.50
Total	13.97

This makes the cost of the hay in the stack $1.60 per ton and not quite $4 baled and delivered on cars. Hitherto most of the alfalfa has been sold as hay, but much better returns are obtained by feeding it to live stock for raising hogs and dairy produce, which undoubtedly constitute the best products for the farmer. Alfalfa usually gives four cuttings in the year, but with care and plenty of water it would be possible to get five cuttings, yielding altogether 5 or 6 tons of hay. Owing, however, to a somewhat slovenly method of farming and the occasional lack of water, the writer places the average yield in the valley at 3½ tons per acre.

VEGETABLE GARDENS.

With very few exceptions all sorts of vegetables are successfully grown in the valley. Very few Irish potatoes are produced, as most of the gardeners have failed to make good crops, owing to their adoption

of the method of culture practiced in rainfall countries. There are, however, a few farmers who succeed in raising good crops every year, and their system is as follows: The land must have been heavily manured, and preferably for a previous crop, for fresh manure is apt to cause the soil to lose its moisture, especially if it is not well incorporated with the soil. Early in winter lay the land up in ridges, and shortly after Christmas give it a good irrigation. At the beginning of February split these ridges and plant in the furrows so made. Cover with a plow and harrow the ground well, so that the surface is in good tilth. By this method sufficient moisture is left in the soil to start the tubers growing without further irrigation. This appears to be the real secret of raising potatoes under irrigation. No water is given until the vines are 8 inches high, when they are earthed up and a good irrigation is applied between the ridges. As a rule, no more water will be needed, but if the land should go dry at the roots, one more irrigation is given. Early varieties are selected, as they set their tubers before the hot weather comes on. One of the farmers at Las Cruces informs me that under this system he has raised crops every year, and that one of which he took the weight and measurement was at the rate of 13½ tons per acre. There consequently appears no reason why all the potatoes required in the valley should not be raised successfully.

Early pease are grown in considerable quantities for shipment to more northern points. They are usually planted on the flat, but it has been found that if the land is laid off in large ridges running east and west and the pease are sown on the southern slope of these ridges the crop will mature several days earlier.

The soil and climate of the Mesilla Valley appear to be admirably adapted to the raising of tomatoes, and, as the canned product compares favorably with the best eastern brands, the raising and canning of tomatoes is likely to prove one of the important industries of the future. The land must be brought into perfect tilth, and if a little manure can be applied it will do all the better. Then lay out the field. Make two small ridges, which will take up, say, 2 or 3 feet, leave a space of 9 feet, and then strike two more ridges. Proceed until the whole field is laid out with two small ridges and a space of 9 feet between each pair of ridges. About half a pound of seed is required to the acre. Sow it along the outside of the ridges, just above the water line, but where the soil will receive a certain amount of moisture by capillary attraction. Then irrigate on the 9-foot spaces as often as the earth dries and cracks, until the small plants are large enough to hoe, after which one irrigation every two or three weeks will suffice.

As soon as the vines begin to run, irrigation must cease in the 9-foot spaces, which must be kept free from weeds, and dry, for the vines to spread over and fruit upon. The water must thereafter be applied in the furrow between the two ridges. The vines should be bent over so that they run over the 9-foot spaces, and in this way they will get dry

soil on which to ripen their fruit. The seed is sown from the middle of April to the beginning of May, and pretty thickly, as there is a small insect that is apt to eat some of the plants. They can be thinned out from 2 to 2½ feet in the rows. Sowing in a hot bed and transplanting has been tried, but is not favored; the plants get such a check in lifting that they are little, if any, ahead of those sown in the field.

If the plants do well they will produce an enormous weight of tomatoes—25,000 to 30,000 pounds. Last year the price paid was 75 cents per 100 pounds; but 50 cents is a fair return. There is a certain amount of risk attached to the cultivation of tomatoes. Even when the plants are up there is the risk of the vines being attacked by a disease which rots them just above the ground and has caused great losses during past years. A remedy for this has been found in spraying the vines with a weak solution of bordeaux mixture.

ORCHARDS AND VINEYARDS.

Among the native Mexicans the grape is the principal fruit raised in the valley, although many of the American farmers own good vineyards. The former grow the Mission grape almost exclusively, whereas the latter mostly raise the Muscat of Alexandria, Black Hamburg, Gros Colmar, Malvoisie, and other so-called California varieties, all of which thrive perfectly.

The grapes begin to ripen toward the end of July, and the shipping season usually lasts till about the last week in October. A great deal of wine is made, but it is usually more profitable to sell the fruit for table use. During the season large quantities are shipped, mostly in 10-pound baskets, to all the towns in New Mexico, and to many of the markets of Arizona, Colorado, Texas, Louisiana, etc.

The vineyards are usually started by putting a couple of cuttings during March every 8 feet each way, although many of the older vineyards are set at 6 feet apart. When the cuttings begin to grow the weaker one is pulled out and the stronger left. The object of setting two cuttings is to make sure of one growing. At 8 feet apart each way 680 vines go to the acre, and this seems to be a better distance than 6 feet, as it gives more room for cultivation. Some of the more progressive horticulturists consider that the rows 10 feet apart and the vines 8 feet apart in the row (544 to the acre) is still better.

What is known as the "stump" method of training and pruning is followed. This consists in staking the vine during the first two years, so as to form a straight upright trunk. The first year the vine is allowed to grow as it pleases, when it is cut back to its strongest eye. The second year all the buds are rubbed off to the height of 15 or 18 inches, and at the next pruning the cane is cut back to 18 or 20 inches, leaving two or three buds as a basis for the future head. From now the "short spur" system of pruning is adopted; that is, the canes are all allowed to grow as they please during summer, and at the annual

pruning in March these canes are cut back to one or two eyes, from which spring the bearing canes. Of course, as the vines get old too many spurs are made and many of them too long, when some must be cut out altogether. Under this system most of the grapes seem to thrive very well, although there is a great deal of very careless staking and training in the early life of the vines, resulting in difficult pruning later on, and many of the bunches get spoiled by the mud, owing to the want of a good, strong, straight trunk to hold up the fruit.

There is considerable difference of opinion as to whether the grape vines need to be hilled up during the winter in this valley. The old custom among the natives has been to cover the vines with hills of earth in the month of November and not to uncover until the following March, when it is time to prune. The mounds of earth are raised sufficiently high to just cover the buds which are to be left for the coming year. No irrigation is given during the winter or until after pruning.

The object of this hilling up is not to protect the vines so much from the winter cold as from the cold, drying winds, which cause the trunk to crack and the canes to winter-kill. It is, however, claimed by those who have tried it in recent years that if the vineyards be irrigated during the winter these dry, cold winds do no harm and the vines thrive better. Pruning is usually done in March, but earlier grapes are produced when the vines are pruned in the fall.

As a general rule the cultivation of the vineyards is most slovenly, and this remark applies quite as much to those owned by Americans as to the Mexican vineyards. Indeed, the latter are, on the whole, better cared for. There is rarely any real cultivation of the soil during summer, and only when the weeds get too rampant are men sent in with hand hoes. Undoubtedly much better results would be obtained if the vines were wider apart, better trained, and the surface soil kept well pulverized throughout the year. There would also be less injury from drought, for the vine is deeply rooted and can stand a long time without water if otherwise properly cared for.

Next to the grape the peach has hitherto proved the most successful fruit raised in the valley. The tree comes to maturity very early and bears enormously. The quality of the fruit is also excellent and will compare favorably with that raised in any other part of the United States. If carefully pruned and the fruit thinned out, the peach tree is also long lived in this valley.

Young trees one year old from the bud are always used in setting out an orchard, and as the peach tree at six or seven years old will cover a space of ground 7 to 8 yards in diameter they are usually set out 24 feet by 21, at which distance an acre will contain 86 trees. Corn, beans, or vegetables are generally grown between the rows for the first two years, but many experts are of opinion that the trees will grow better if the land is kept clear and well cultivated.

The peach tree, and indeed all other fruit trees, are headed low in

pruning, so as to protect the trunks and ground from the scorching sun. The first branches are usually started about 2 to 3 feet from the ground, sometimes much lower.

Nearly if not quite as many apple trees have been set out as peach trees, but owing to the longer time required to come to maturity, fewer orchards are in bearing. As previously remarked, any variety that makes a good peach in other parts of the world will do the same in New Mexico, and the same rule applies to grapes, plums, and, to a great extent, pears. But in the case of the apple the climate and probably the soil and water have a very marked effect in changing the color, quality, and time of ripening and keeping of the apples, so that especial varieties have to be chosen to suit the climate, etc.

As regards the general character and quality of the apples raised, it may be said that in size and beauty of coloring they are unsurpassed; but they are of only fair quality and do not keep long. Nevertheless, this may be classed as a good apple country when one considers that the apple is a sure cropper every year and that this is the most southern locality in which this fruit can be profitably cultivated.

As in the case of the peach, yearling trees are the best to set out. Two-year-old trees, however, do well, but it is not advisable to use older plants. The best distance to plant seems to be 24 by 21 feet, and in pruning they must be headed low. So far as one is able to judge, the apple is not a very long-lived tree in this climate, owing largely, I believe, to the fact that the trees are allowed to overbear year after year. Experiments made by me prove that it would pay to thin out the fruit in the same way that peaches are thinned out.

The climate seems admirably adapted to the cultivation of pears, plums, and prunes, and they are less subject to frost than peaches, although not such a sure crop as apples. All sorts of pears and plums grow to the greatest perfection. Up to the present time no prunes have been cured, but the trees thrive, and the dry, sunny climate ought to make this industry a profitable one.

Besides the fruits already mentioned, quinces and mulberries grow to perfection. Melons and cantaloupes are also raised and shipped in large quantities. Peanuts do well, but very few have been raised for market. All sorts of small grain thrive in the valley, and the very finest samples of wheat have been raised. The land and climate are also admirably adapted to beet-culture and tobacco. Canaigre, the new tanning plant, grows wild on the adjoining plains, and it is probable that when this plant comes into more general use a considerable industry will spring up in the valley.

One of the greatest errors made by the earliest settlers was to sow down their orchards with alfalfa. Doubtless the mistake arose from the fact that orchards in the East are advantageously sown with white clover. The latter, however, is a shallow-rooted plant, whereas the alfalfa at three or four years of age will have roots far larger and deeper

than those of an apple tree, and the inevitable result has always been that the alfalfa prevented the growth and ultimately caused the death of the fruit trees. Even if sown in an established orchard the alfalfa will so rob the soil that no good fruit will be produced, and in the end the alfalfa surely kills the trees.

The earliest planted orchards were invariably supplied with a wind-break, mostly composed of osage orange, and occasionally of cotton-wood or Russian mulberry trees. All these wind-breaks had the same defects—they gave no protection to the newly planted fruit trees, unless the wind-break was set four or five years in advance; and nothing would grow near the trees used as a wind-break, owing to their robbing the soil of all nutriment for a considerable distance. The osage orange had one advantage—it provided an impenetrable fence.

The Mexicans had, as a rule, surrounded these vineyards with an adobe or mud wall, which, while making a perfect wind-break, afforded a too comfortable winter resort for the codling-moth grub and other noxious insects. Ultimate experience showed that the best and only wind-break needed was, as a friend facetiously remarked, a good barbed-wire fence. If there be any advantage in a wind-break, possibly the best thing to do would be to plant a row of wild-goose plum trees, about 10 feet apart. They would bear a profitable crop every year, and form an almost impenetrable thicket.

For the vegetable garden, however, a wind-break is absolutely necessary to protect the young growing plants from the destructive effects of the bleak winds in February and March. An adobe wall is perhaps the best protection, or a fence may be made of lumber, or even of the walking-cane cactus, which grows plentifully on the adjoining table-lands. This latter will last eight or ten years, and is impassable by man, pigs or poultry.

The valley is not exempt from late spring frosts, which occasionally do considerable damage to the fruit blossoms. These frosts, however, are not worse than those occurring in almost every other fruit district, and their injurious effects can be considerably mitigated by means of irrigation. The trees most liable to injury are the almond and apricot, owing to the earliness of their blossoming; and on this account they are seldom planted. Peaches are also cut off two or three years out of seven; but apples and grapes are very seldom injured, and there are apple orchards and vineyards which have not failed to produce a good crop annually for the past fourteen years. Pears and plums are liable to suffer more often than apples, but are a much more certain crop than peaches.

ADVANTAGES OF IRRIGATION.

When the Eastern farmer sees all the work entailed in laying out a wheat field for irrigation and the subsequent labor of applying the water, he is often heard to exclaim, "If all that work is necessary I have no use

for irrigation." It is useless to attempt to disguise the fact that irrigation entails much expense in the cultivation of crops. Of course, that expense varies with the kind of crop raised; but the question may be asked whether the value of the extra quantity produced is not in excess of the extra expenditure.

Let us take the case of alfalfa. The yearly expense per acre for irrigation, as has already been shown, is $2.15; but four crops of hay are raised in the year in lieu of one without irrigation, or say 3½ tons instead of 1½ tons. The farmer therefore gets an extra 2 tons of hay for an expenditure of $2.15 in water. Add $2 for the cost of harvesting these 2 tons, and you have an extra 2 tons of hay costing $4.15, or $2.08 per ton.

In the case of wheat crop it is not easy to give exact figures, but I have no hesitation in saying that the crop will be double what it is in countries where irrigation is not practiced and where fertilizers are not used. This is due in large part to the fertilizing properties of the river water, to which reference has already been made, which insures the permanent fertility of the soil. One must also bear in mind the fact that wheat and almost all farm products are worth more in the irrigated districts of the West than they are farther east.

No farmer would consider it a waste of money to put 10 tons per acre of barnyard manure upon his land every year, even though it cost him $6. For half this expense he can, where the river water is of the same quality as that which irrigates the Mesilla Valley, not only apply fertilizers equal to the contents of 10 tons of barnyard manure, but he gives the crop the exact amount of water required for a full yield, insures it against loss by drought, and gets a better price than could be obtained elsewhere. Irrigation farming means intensive farming; and it is intensive farms which pay in the long run.

If the question is asked, as it often is, What is the most profitable product to raise in New Mexico? the answer generally made is that apples, peaches, grapes, or some fancy crop will pay the most money, and dazzling figures are given showing the number of pounds per acre and cents per pound, resulting in a rapid fortune from 40 acres of land In my opinion, however, the future of farming in New Mexico does not lie in this direction.

I have elsewhere referred to the feeding qualities of alfalfa, especially when mixed with corn or sorghum fodders and corn meal. The climate, soil, and irrigation of the Mesilla Valley, and of many other valleys on the Rio Grande, are especially adapted to raising these crops, and I believe that the future of farming here lies in feeding alfalfa and corn for the production of beef, pork, and dairy products.

There is an abundance of range cattle, which up to the present time are shipped to Eastern points and there fattened for market, while right here are all the means of fattening these cattle. If the cattle were fattened at home, not only could they be shipped more profitably, but there would be a remunerative market at home.

The advantages of stock-feeding over fruit-growing are many. In the first place, the stock give an immediate return, whereas no returns can be expected from fruit for four and often six years. Then, again, there are more farmers who understand stock-raising than there are who understand fruit-growing. Moreover, there are many risks attached to an orchard which are absent from a stock farm, especially in the matter of prices obtainable for the produce. Pork, beef, and butter are always in steady demand and at cash prices, and the stock farmer is not liable to losses from gluts in the market, which so often beset the orchardist. It may seem strange to predict that the great future of farming in one of the finest fruit valleys in the world is in stock rather than in fruit, but it will not be the first instance of the kind.

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CHARLES D. WALCOTT, DIRECTOR

RIVER HEIGHTS FOR 1896

BY

ARTHUR POWELL DAVIS

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, June 1, 1897.

SIR: I have the honor to transmit herewith a series of tables pertaining mainly to river heights, prepared by the Division of Hydrography of this Survey, and to recommend that it be published in the series of papers "in relation to the gauging of streams and to the methods of utilizing the water resources," the printing of which was authorized in the act making appropriations for sundry civil expenses of the Government for the fiscal year ending June 30, 1897, approved June 11, 1896.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

RIVER HEIGHTS FOR 1896.

By ARTHUR P. DAVIS.

DAILY GAGE HEIGHTS OBSERVED DURING 1896.

The series of tables here presented pertain mainly to the river heights observed and recorded during 1896 by persons employed by or cooperating with the Division of Hydrography of this Survey. There are also included a few tables obtained from the Weather Bureau through the courtesy of Hon. Willis L. Moore, chief of that Bureau. These give the heights of water at points near localities where measurements have been made by hydrographers of this Survey, and are of value in computations of discharge. A few similar tables have been obtained through officers of the Engineer Corps of the United States Army, from observations made in connection with investigations pertaining to the improvement of navigation. There are appended tables of evaporation, seepage, meter ratings, and other similar details to which reference is made by hydrographers of this Survey.

These tables pertain to the progress report of stream measurements for 1896, prepared by the Division of Hydrography and printed in Part IV of the Eighteenth Annual Report of the Survey. They might properly have been included in the progress report, but since they relate to minor details and have a comparatively limited application, it has been thought best, from considerations of economy and from the necessity of reducing the size of the annual report, to include these in a separate publication of more limited distribution. On the other hand, these data should be printed and thus made available for the use of hydrographers, not only those connected with this Survey, but others occupied in similar examinations throughout the country.

Patapsco River at Woodstock, Maryland.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.55	3.85	3.70	4.05	17	3.70	3.60	3.70	.....	3.65
2	.....	3.50	3.65	3.70	4.00	18	3.70	3.60	3.70	.....	3.70
3	.....	3.45	3.60	3.70	3.95	19	3.70	3.60	3.65	3.90	3.65
4	.....	3.50	3.60	3.75	3.75	20	3.65	3.60	3.65	3.70	3.45
5	.....	3.65	3.65	3.90	3.75	21	3.55	3.70	3.70	3.65	3.65
6	3.60	3.85	3.65	4.10	3.85	22	3.35	3.20	3.70	3.70	3.65
7	3.70	3.85	3.65	3.95	3.90	23	3.40	3.60	3.70	3.75	3.65
8	3.60	3.60	3.50	3.85	3.70	24	3.65	3.50	3.65	3.70	3.60
9	3.50	3.55	3.70	4.10	3.75	25	3.65	3.55	3.75	3.65	3.50
10	3.80	3.50	3.65	4.00	3.75	26	3.55	3.50	3.80	3.50	3.65
11	3.60	3.50	3.70	3.85	3.70	27	3.70	3.55	3.70	3.65	3.65
12	3.70	3.50	3.85	3.80	3.70	28	3.50	3.50	3.70	3.65	3.85
13	3.85	3.45	3.95	3.80	3.70	29	3.40	3.60	3.70	4.90	3.85
14	3.85	3.55	3.80	3.80	3.75	30	3.55	3.40	3.70	4.20	3.50
15	3.75	3.55	3.75	3.80	3.65	31	3.35	.....	3.70	.....	3.75
16	3.70	3.65	3.65	4.00	3.65						

Patuxent River at Laurel, Maryland.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	4.20	4.75	3.15	4.75	17	4.60	4.50	3.80	4.50	4.40
2	.....	4.00	4.30	4.35	4.85	18	4.00	3.75	3.10	4.40	4.55
3	4.30	4.00	3.80	3.05	4.65	19	4.10	4.35	3.85	4.50	4.40
4	4.30	3.50	3.20	4.40	4.70	20	4.60	5.10	3.90	4.50	3.20
5	4.10	4.20	3.95	4.60	4.75	21	4.60	3.90	4.45	4.50	4.60
6	4.20	4.50	3.75	4.65	3.95	22	4.40	3.75	4.30	3.00	4.50
7	4.00	4.00	3.80	4.80	4.85	23	3.60	3.65	4.45	4.65	4.30
8	4.00	3.30	3.75	3.25	4.75	24	4.40	3.80	4.40	4.30	3.85
9	3.50	3.30	3.75	4.80	4.75	25	4.60	3.70	3.25	4.30	4.15
10	3.90	4.30	3.80	4.45	4.70	26	4.60	3.80	4.60	3.15	4.25
11	4.30	2.30	3.10	4.70	4.55	27	4.50	3.05	4.55	4.55	4.05
12	4.10	4.50	3.90	4.50	4.65	28	4.50	3.70	4.15	4.20	4.25
13	4.10	2.20	3.80	4.60	3.85	29	4.40	3.70	3.95	5.50	4.70
14	4.30	2.90	3.90	4.45	4.60	30	2.70	4.85	4.10	5.00	4.65
15	4.50	4.50	3.80	3.55	4.65	31	4.70	.....	3.95	.....	4.90
16	3.60	4.70	3.80	4.60	4.60						

Potomac River at Cumberland, Maryland.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.90	4.60	3.90	5.00	4.50	3.60	3.10	3.80	2.60	5.50	3.10	3.70
2	2.90	4.80	3.70	4.80	4.50	3.50	3.10	3.80	2.70	4.50	3.10	3.50
3	3.00	4.00	3.00	4.40	4.50	3.40	3.10	3.80	2.70	4.50	3.10	3.40
4	2.90	3.80	3.30	4.20	4.50	3.50	3.10	3.70	2.70	3.50	3.20	3.30
5	2.90	3.80	3.10	3.80	3.40	3.30	3.10	3.30	2.70	3.40	3.20	3.30
6	2.90	3.80	3.10	3.80	3.30	3.30	2.90	3.30	2.80	3.30	5.50	3.30
7	2.90	4.50	3.10	3.70	3.10	3.80	2.90	3.20	2.90	3.10	4.50	3.30
8	2.90	3.90	3.60	3.70	3.00	3.70	2.90	3.20	2.90	3.10	3.80	3.20
9	2.90	3.00	3.40	3.70	3.00	3.40	3.10	3.40	2.90	3.10	3.80	3.30
10	2.90	3.40	3.30	3.70	3.00	3.40	3.70	3.40	2.90	3.00	3.70	3.30
11	2.90	3.10	3.30	3.70	2.90	3.40	3.40	3.30	2.80	3.00	3.60	3.40
12	3.00	3.30	3.40	4.30	2.90	3.40	3.30	3.30	2.70	3.10	3.50	3.60
13	3.00	4.90	3.10	4.30	3.50	3.20	3.10	3.10	2.90	3.10	3.50	3.40
14	3.00	4.10	3.10	4.10	3.50	3.20	3.00	3.60	3.00	3.00	3.40	3.30
15	3.00	3.80	3.10	3.90	3.30	3.30	3.00	3.50	3.10	3.00	3.20	3.30
16	3.00	3.80	3.20	3.80	3.20	3.30	3.00	3.30	3.50	3.00	3.10	3.30
17	3.00	3.50	3.30	3.80	3.10	3.70	3.00	3.10	3.00	3.00	3.10	3.30
18	3.00	3.50	3.30	3.70	3.40	4.10	3.30	3.00	3.00	3.00	3.20	3.20
19	2.90	3.20	3.50	3.50	3.50	3.70	3.10	2.90	3.00	2.90	3.30	3.30
20	2.90	3.20	3.60	3.50	3.80	3.60	3.10	2.90	2.90	2.90	3.30	3.30
21	3.00	3.20	3.70	3.50	3.80	3.30	3.30	3.00	3.00	3.10	3.20	3.20
22	3.00	3.20	3.70	3.50	3.60	3.30	4.00	3.00	3.10	3.10	3.30	3.20
23	3.00	3.30	4.00	3.30	3.40	3.20	4.70	3.00	3.10	3.10	3.30	3.20
24	3.10	3.10	3.90	3.40	3.40	3.50	4.60	3.20	3.00	3.30	3.40	3.20
25	3.50	3.30	3.70	3.50	3.50	3.50	10.00	3.00	3.00	3.70	3.30	3.20
26	3.30	3.30	4.00	3.50	3.50	3.60	6.50	2.90	3.00	3.50	3.30	3.20
27	3.10	3.30	5.00	3.50	4.00	3.50	4.70	2.90	3.00	3.20	3.20	3.10
28	3.00	3.20	4.50	3.50	3.70	3.30	4.90	2.90	2.90	3.20	3.20	3.10
29	3.00	3.70	5.80	3.50	4.10	3.80	4.50	2.90	2.90	3.10	3.90	3.10
30	3.70	.....	8.00	3.40	4.00	3.20	4.50	2.90	10.00	3.10	4.00	3.10
31	4.20	.....	6.00	.....	3.80	.....	4.50	.....	.....	3.10	.....	3.20

North River at Port Republic, Virginia.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.00	2.50	2.60	5.40	2.32	2.42	2.80	2.43	2.00	7.50	2.35	4.40
2	2.70	2.50	2.60	5.00	2.52	2.32	2.70	2.43	1.95	4.50	2.35	3.50
3	2.50	2.80	2.60	4.60	2.52	2.32	2.70	2.55	1.90	4.00	2.35	3.30
4	2.40	3.80	2.60	4.20	3.32	2.22	2.60	2.45	1.90	3.50	2.35	3.30
5	2.40	3.80	2.60	4.00	3.32	2.20	2.60	2.40	1.90	3.30	4.70	3.25
6	2.40	5.00	2.50	3.60	3.32	2.20	2.80	2.40	1.85	3.20	6.00	3.10
7	2.40	5.70	2.50	3.50	3.12	4.50	2.80	2.30	1.85	3.10	4.30	3.05
8	2.30	4.50	2.50	3.50	2.92	3.00	2.80	2.30	1.80	3.00	3.60	2.90
9	2.30	4.10	2.50	3.40	2.72	2.60	7.50	2.30	1.80	2.90	3.30	2.80
10	2.30	3.70	2.50	3.30	2.72	2.50	5.30	2.25	1.75	2.80	3.30	2.70
11	2.30	3.50	2.40	3.30	2.72	2.30	3.90	2.20	1.70	2.65	3.20	2.65
12	2.30	3.30	2.40	3.20	2.62	2.30	3.60	2.20	1.70	2.55	3.00	2.60
13	2.30	3.30	2.40	3.20	2.52	2.20	3.30	2.20	1.70	2.50	2.80	2.55
14	2.20	5.20	2.40	3.00	5.82	2.20	3.00	3.60	1.70	2.50	2.80	2.55
15	2.20	4.70	2.60	3.00	3.82	2.20	3.30	2.70	2.00	2.50	2.70	2.50
16	2.10	3.80	2.60	(a)	3.22	2.20	3.00	2.70	1.90	2.50	2.70	2.50
17	2.10	3.60	2.80	.....	3.02	2.50	3.10	3.00	1.80	2.50	2.65	2.45
18	2.00	3.10	3.20	.....	2.82	2.40	2.70	2.40	1.80	2.45	2.65	2.45
19	2.00	3.00	4.80	.....	2.62	2.40	2.70	2.30	1.80	2.45	2.60	2.45
20	2.00	2.70	7.20	.....	2.62	3.30	2.70	2.25	1.70	2.40	2.60	2.45
21	2.00	2.70	5.00	.....	2.62	3.00	2.60	2.25	1.70	2.40	2.55	2.45
22	2.00	2.70	4.80	.....	2.62	2.90	2.50	2.25	1.70	2.35	2.50	2.45
23	2.10	2.70	4.00	.....	2.62	2.50	2.50	2.20	1.70	2.35	2.50	2.45
24	6.15	2.70	3.80	.....	2.52	2.40	2.50	2.20	1.65	2.35	2.45	2.45
25	5.30	2.70	3.50	.....	2.52	2.40	3.00	2.40	1.65	2.35	2.40	2.40
26	4.00	2.60	3.50	.....	2.52	3.20	2.70	2.20	1.65	2.35	2.40	2.40
27	3.30	2.60	3.50	.....	2.52	3.00	2.70	2.20	1.65	.....	2.35	2.40
28	3.00	2.60	3.50	b 2.22	2.42	3.00	2.60	2.15	1.65	2.35	2.35	2.40
29	2.80	2.60	4.40	2.22	2.42	2.90	2.60	2.15	7.21	2.35	3.00	2.40
30	2.60	.....	6.50	2.22	2.42	2.90	2.50	2.10	18.00	2.35	5.50	2.40
31	2.50	.....	5.90	.....	2.42	.....	2.45	2.10	.....	2.35	.....	2.35

a Gage carried away. *b* New gage.

South River at Port Republic, Virginia.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.80	2.00	2.00	3.20	1.70	1.60	1.80	1.50	1.40	5.00	1.60	2.70
2	1.80	2.00	2.00	3.00	1.70	1.50	1.80	1.50	1.40	3.30	1.60	2.55
3	1.80	2.30	2.00	2.80	2.20	1.50	1.70	1.50	1.40	3.00	1.60	2.40
4	1.70	2.50	2.00	2.70	2.20	1.50	1.60	1.50	1.40	2.75	1.60	2.40
5	1.60	2.50	2.00	2.50	2.20	1.50	1.60	1.50	1.40	2.40	4.10	2.35
6	1.50	3.15	1.90	2.50	2.20	1.50	1.70	1.45	1.40	2.30	3.50	2.10
7	1.40	3.60	1.90	2.40	2.10	2.50	1.70	1.45	1.40	2.30	3.00	2.10
8	1.40	3.10	1.90	2.30	2.00	2.50	1.70	1.40	1.40	2.20	2.60	2.00
9	1.30	3.10	1.90	2.30	1.90	2.50	4.80	1.40	1.40	2.10	2.40	1.90
10	1.30	2.70	1.90	2.20	1.90	2.00	3.20	1.40	1.40	2.00	2.30	1.80
11	1.30	2.50	1.85	2.20	1.90	1.80	2.70	1.40	1.40	2.00	2.15	1.70
12	1.30	2.30	1.85	2.20	1.80	1.80	2.50	1.40	1.40	1.95	2.15	1.60
13	1.30	2.30	1.85	2.20	1.70	1.70	2.40	1.40	1.35	1.95	2.10	1.50
14	1.20	2.80	1.85	2.15	3.00	1.60	2.30	2.00	1.35	1.90	2.10	1.50
15	1.20	2.70	2.00	2.15	2.00	1.60	2.30	1.60	1.35	1.85	2.00	1.50
16	1.20	2.50	2.00	2.10	1.80	1.60	2.00	1.60	1.35	1.85	2.00	1.45
17	1.20	2.40	2.20	2.00	1.80	2.50	2.00	1.60	1.35	1.85	1.90	1.45
18	1.20	2.30	2.20	2.00	1.70	2.20	1.70	1.50	1.35	1.85	1.90	1.45
19	1.20	2.30	2.80	1.90	1.60	2.20	1.80	1.50	1.35	1.85	1.85	1.45
20	1.20	2.20	4.30	1.90	1.60	2.50	1.80	1.50	1.35	1.80	1.85	1.45
21	1.20	2.20	3.00	1.90	1.60	2.00	1.70	1.50	1.35	1.75	1.80	1.45
22	1.20	2.20	2.60	1.80	1.60	2.00	1.70	1.50	1.30	1.70	1.80	1.45
23	1.30	2.10	2.60	1.80	1.60	1.80	1.70	1.50	1.30	1.65	1.80	1.45
24	4.90	2.10	2.50	1.80	1.60	1.70	1.70	1.50	1.25	1.65	1.80	1.45
25	3.60	2.10	2.50	2.00	1.60	1.70	1.70	1.65	1.25	1.65	1.75	1.45
26	3.00	2.00	2.40	2.00	1.60	2.00	1.70	1.50	1.25	1.65	1.70	1.45
27	2.70	2.00	2.40	1.90	1.60	2.00	1.70	1.50	1.25	.....	1.65	1.45
28	2.40	2.00	2.40	1.80	1.60	2.00	1.70	1.50	1.25	1.60	1.65	1.45
29	2.30	2.00	2.50	1.75	1.60	1.90	1.60	1.50	9.69	1.60	2.00	1.45
30	*2.20	.....	3.30	1.70	1.60	1.90	1.60	1.45	17.00	1.60	3.10	1.45
31	2.10	.....	3.20	.....	1.60	.....	1.50	1.45	.....	1.60	.....	1.45

Shenandoah River at Millville, West Virginia.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.30	1.40	2.60	4.60	1.40	0.90	1.60	1.30	0.70	19.72	0.90	2.60
2	1.90	1.60	2.40	4.20	1.40	.90	1.60	1.20	.60	10.00	.90	3.80
3	1.80	1.80	2.30	3.80	1.50	.90	1.50	1.10	.60	5.60	.90	3.10
4	1.80	2.00	2.00	3.60	1.70	.90	1.50	1.00	.60	4.00	.90	2.60
5	1.70	2.60	1.70	3.20	1.80	.90	1.50	1.00	.60	3.40	1.00	2.00
6	1.60	2.90	1.50	2.80	1.90	.80	1.50	1.00	.60	2.80	1.10	2.00
7	1.60	3.80	1.40	2.60	2.40	1.00	1.60	1.10	.50	2.10	3.20	2.00
8	1.60	5.60	1.50	2.60	2.20	1.40	1.60	1.10	.50	2.00	2.70	2.00
9	1.40	4.10	1.50	2.00	2.00	1.90	3.15	1.00	.50	1.90	2.40	2.00
10	1.30	3.70	1.50	2.00	2.00	2.70	4.65	1.00	.50	1.80	2.10	2.00
11	1.30	3.20	1.50	2.00	1.90	2.80	3.60	1.00	.60	1.80	1.90	1.90
12	1.20	2.90	1.40	2.00	1.70	2.40	2.50	1.40	.60	1.60	1.90	1.90
13	1.20	2.50	1.40	2.00	1.70	1.60	2.20	1.60	.60	1.40	1.90	1.80
14	1.00	2.40	1.40	1.90	1.60	1.60	2.20	1.50	.60	1.40	1.90	1.80
15	1.00	3.80	1.50	1.70	2.40	1.90	2.20	1.40	.60	1.40	1.90	1.70
16	1.00	3.50	1.50	1.70	3.00	1.90	2.20	1.40	.60	1.40	1.80	1.70
17	1.00	3.00	1.60	1.60	2.50	1.80	2.10	1.70	.60	1.30	1.70	1.70
18	1.00	2.70	3.00	1.60	2.40	1.90	2.00	1.30	.60	1.30	1.60	1.70
19	1.00	2.50	4.20	1.60	2.40	2.20	2.00	1.30	.60	1.30	1.60	1.70
20	1.00	2.40	4.60	1.50	2.20	2.00	1.80	1.20	.80	1.20	1.50	1.60
21	.90	2.40	5.50	1.50	1.80	1.90	1.60	1.20	.80	1.10	1.50	1.50
22	.90	2.30	4.60	1.50	1.60	2.00	1.50	1.20	.80	1.10	1.50	1.50
23	.90	2.20	4.00	1.50	1.50	2.20	4.10	1.00	.70	1.00	1.50	1.40
24	2.40	2.20	3.50	1.50	1.60	2.00	3.00	1.00	.60	1.00	1.50	1.40
25	5.10	1.80	3.00	1.50	1.50	1.90	3.30	1.00	.60	1.00	1.40	1.60
26	5.30	1.70	2.90	1.40	1.50	1.80	2.60	.90	.60	1.00	1.40	1.60
27	4.35	1.60	2.80	1.40	1.50	1.80	2.00	.90	.60	1.00	1.40	1.60
28	3.35	1.50	2.70	1.40	1.40	2.20	1.70	.80	.60	1.00	1.40	1.80
29	2.00	2.00	2.70	1.40	1.40	2.30	1.50	.80	.60	1.00	1.40	1.80
30	1.90	.....	2.60	1.40	1.40	1.90	1.40	.80	5.75	1.00	1.60	1.80
31	1.70	.....	4.60	.....	1.10	.....	1.30	.80	.....	.90	.....	1.80

Potomac River at Point of Rocks, Maryland.

Day.	Jan.	Feb.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.30	1.30	.....	1.10	1.60	2.00	0.50	21.85	0.80	2.00
2	1.20	1.20	.....	.80	1.40	2.20	.50	12.05	.80	3.00
3	1.30	1.30	.....	.60	1.20	2.50	.40	6.30	.70	2.80
4	1.40	1.80	.....	.50	1.10	2.00	.40	4.00	.70	2.30
5	.40	2.80	.....	.40	1.00	1.80	.40	3.00	.80	2.00
6	1.40	3.50	.....	.30	1.30	1.60	.50	2.40	6.00	1.80
7	1.30	6.80	.....	.60	1.20	1.40	.30	2.10	6.00	1.70
8	1.30	7.00	.....	.60	1.60	1.20	.30	1.80	5.10	1.70
9	1.30	5.00	.....	1.60	1.90	1.10	.30	1.50	3.80	1.60
10	1.30	3.80	.....	2.00	2.50	1.20	.30	1.30	3.00	1.50
11	1.00	3.90	0.80	2.20	4.00	1.10	.40	1.20	2.50	1.70
12	.80	2.80	.70	1.70	3.80	1.00	.30	1.10	2.20	1.70
13	.70	2.40	.60	1.40	2.70	1.00	.30	1.10	1.90	1.60
14	.60	2.30	.60	1.10	2.30	1.10	.30	1.00	1.70	1.50
15	.50	2.70	.50	1.00	2.30	1.10	.30	1.00	1.50	1.40
16	.50	3.90	1.60	1.10	1.00	1.10	.80	1.00	1.50	1.30
17	.50	3.50	1.10	1.20	1.50	1.20	.50	1.00	1.40	1.20
18	.40	2.90	1.00	3.40	1.40	1.00	.40	1.00	1.30	1.10
19	.30	2.30	.80	3.20	1.40	.80	.40	.90	1.20	1.00
20	.30	1.30	.60	2.70	1.30	.70	.70	.90	1.10	1.00
21	.30	.90	.60	2.20	1.20	.60	.40	.80	1.00	1.00
22	.50	1.10	.70	1.80	1.10	.60	.50	.80	1.00	1.00
23	.60	1.50	1.00	1.80	1.20	.60	.40	.80	1.00	1.00
24	2.30	1.50	1.00	1.80	1.60	.60	.40	.70	1.00	1.00
25	4.90	1.60	.90	1.60	3.30	.60	.30	.70	.90	.90
26	4.80	1.40	.80	1.70	8.70	.50	.40	.90	.90	1.10
27	3.70	1.30	.70	1.90	6.00	.50	.40	1.00	.90	1.00
28	2.90	1.20	.60	2.30	3.30	.50	.30	.90	1.00	.70
29	2.10	1.80	.80	2.00	2.70	.60	.40	.90	1.00	.70
30	1.60	.....	1.00	1.80	2.80	.60	5.30	.80	1.20	.80
31	1.40	.....	1.60	.....	2.40	.50	.....	.80	.....	.90

Monocacy River at Frederick, Maryland.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.60	4.80	3.90	4.80	17	3.80	3.90	4.00	4.20	4.00
2	.....	3.60	4.40	4.00	4.50	18	4.40	3.90	3.90	4.20	4.00
3	.....	3.60	4.10	4.00	4.50	19	4.15	4.00	3.90	4.20	4.00
4	4.10	3.60	4.00	4.00	4.30	20	3.90	4.00	3.80	4.20	4.00
5	4.10	3.60	3.90	5.45	4.30	21	3.90	4.00	3.90	4.20	4.00
6	4.00	3.70	3.90	7.50	4.10	22	3.90	3.90	3.90	4.00	3.90
7	4.00	3.80	3.90	5.00	4.10	23	3.80	3.90	3.90	4.00	3.90
8	3.90	3.90	3.90	4.50	4.10	24	3.70	3.80	3.90	4.00	4.10
9	3.90	3.90	3.90	4.50	4.20	25	3.70	3.90	3.90	4.00	4.20
10	3.90	3.80	3.90	4.80	4.20	26	3.90	3.80	3.90	4.00	4.10
11	3.80	3.70	3.80	4.50	4.30	27	3.90	3.80	3.90	4.00	4.10
12	3.90	3.70	3.80	4.50	4.20	28	3.80	3.80	3.90	4.00	4.10
13	3.90	3.70	3.90	4.30	4.10	29	3.70	3.80	3.90	4.35	4.00
14	3.90	3.70	4.20	4.30	4.10	30	3.60	5.00	3.90	5.20	4.00
15	3.90	3.70	4.10	4.20	4.10	31	3.70	.....	3.90	.....	4.20
16	3.80	a3.75	4.10	4.20	4.10						

a New gage.

North River at Glasgow, Virginia.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.50	1.80	1.90	5.25	.....	1.40	1.50	1.55	1.42	5.03	1.59	4.13
2	2.05	1.50	1.80	.....	.....	1.33	1.36	3.35	1.38	3.70	1.60	3.42
3	1.85	3.50	1.80	3.00	.....	1.25	1.32	2.24	1.40	2.90	1.60	2.50
4	(a)	2.80	1.76	.....	.....	1.30	1.50	1.90	1.46	2.70	1.60	2.50
5	1.33	(a)	1.72	.....	2.33	1.28	1.60	1.76	1.35	2.60	4.75	.....
6	1.35	4.20	1.68	2.76	2.12	1.23	1.40	1.54	1.35	2.40	4.85	2.40
7	(a)	4.15	1.63	2.60	1.97	1.23	3.22	1.62	1.38	2.30	3.35	2.30
8	1.37	4.35	1.62	2.40	1.86	1.24	(a)	1.50	1.35	2.15	2.90	2.20
9	1.40	.....	1.62	2.37	1.84	2.20	8.45	1.44	1.33	2.08	2.65	2.15
10	1.30	3.85	1.60	.....	1.84	1.95	4.45	1.36	1.30	2.00	2.42	2.11
11	1.25	2.60	(a)	.....	.....	1.60	3.50	1.32	1.28	1.96	2.30	2.01
12	1.22	2.50	1.66	.....	.....	1.42	.....	1.30	1.26	1.90	2.21	1.94
13	1.20	2.40	1.60	.....	3.40	1.35	2.78	1.50	.....	1.90	2.22	.....
14	1.20	4.40	1.58	2.02	2.50	1.96	2.40	.....	.....	1.88	2.11	1.90
15	1.18	4.00	1.60	.....	2.25	1.55	2.26	2.00	.....	1.82	2.02	1.90
16	1.15	3.05	2.85	1.94	1.82	1.50	2.20	1.72	.....	1.82	2.05	1.84
17	1.12	2.50	4.93	.....	.....	1.40	2.52	.....	1.00	1.80	2.01	1.80
18	1.12	2.25	3.65	1.90	.....	1.50	2.00	1.72	1.00	1.75	2.02	1.80
19	1.15	2.24	4.20	1.87	.....	1.62	1.82	1.60	1.00	1.71	2.00	1.78
20	1.19	2.14	5.25	.....	2.08	1.96	1.75	1.52	.98	1.70	2.01	1.75
21	1.17	2.05	4.00	.....	2.00	(a)	1.72	1.48	.95	1.71	1.95	1.70
22	1.12	1.95	3.12	1.80	1.74	1.46	1.65	1.40	.95	1.68	.....	1.70
23	(a)	1.90	(a)	.....	1.82	2.08	2.25	2.37	.96	1.70	.....	1.65
24	4.95	1.86	2.90	1.77	1.61	1.47	1.83	1.54	.90	1.70	.....	1.60
25	3.76	1.80	2.80	.....	1.60	1.47	1.80	2.25	.90	1.63	1.67	1.58
26	2.88	1.75	2.77	1.75	1.61	2.26	1.67	1.82	.93	1.67	.....	1.56
27	2.42	1.70	2.61	.....	1.59	2.58	1.60	1.70	.91	1.60	.....	1.56
28	2.20	1.70	2.51	.....	1.63	2.00	1.50	1.60	.90	1.63	.....	1.60
29	2.00	1.90	3.05	.....	1.61	1.74	1.50	1.50	4.04	1.63	.....	1.60
30	1.90	.....	6.72	.....	1.56	1.61	1.60	.....	16.09	1.62	5.60	1.50
31	1.80	.....	5.41	.....	1.45	.....	1.90	1.42	.....	1.62	.....	1.55

a No observation.

Roanoke River at Roanoke, Virginia.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	0.80	0.70	1.95	0.75	2.00	17	1.55	0.80	0.60	0.75	1.40	0.90
2	.....	.90	.65	1.70	.75	1.90	18	1.50	.69	.59	.75	1.30	.95
3	.....	.90	.60	1.40	.75	1.90	19	1.45	.62	.50	.75	1.22	.90
4	.....	.90	.72	1.10	.75	.85	20	1.40	.62	.55	.75	1.10	.85
5	.....	.90	.78	1.00	2.60	.82	21	1.40	.60	.60	.75	1.00	.85
6	.....	.85	.80	.95	2.10	.82	22	1.38	.65	.55	.75	.90	.85
7	.....	.70	.75	.90	1.95	.80	23	1.50	.75	.50	.75	.85	.82
8	.....	.70	.70	.85	1.95	.80	24	1.33	1.03	.50	.75	85	.82
9	.....	.70	.70	.85	1.90	.78	25	1.30	.99	.45	.75	.80	.80
10	3.53	.70	.55	.80	1.85	.78	26	1.25	.81	.50	.75	.75	.80
11	2.80	.90	.50	.80	1.82	.76	27	1.20	.75	.50	.75	1.00	.80
12	2.20	.80	.60	.75	1.80	.75	28	1.20	.75	.55	.75	1.30	.80
13	1.95	.70	.50	.80	1.70	.75	29	1.18	.75	1.33	.75	2.80	.80
14	1.75	.75	.55	.85	1.65	.75	30	.75	.60	3.40	.75	2.45	.75
15	1.63	.80	.52	.80	1.50	.75	31	.85	.75	.....	.75	.....	.75
16	1.53	.74	.65	.75	1.45	.75							

James River at Buchanan, Virginia.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.30	1.30	7.85	—0.60	0.60	0.60	1.00	0.10	5.30	—0.20	4.40
2	.....	1.30	1.30	7.65	— .60	.60	.40	1.50	.00	2.60	— .20	3.15
3	.....	3.25	1.30	5.05	+1.30	.50	.30	1.30	—.10	1.65	— .20	2.40
4	.....	5.60	1.30	3.85	1.55	.50	.30	1.05	—.10	1.25	— .20	1.85
5	.....	3.90	1.30	2.90	1.05	.35	.30	.90	—.20	.85	+4.10	1.65
6	.....	3.80	1.30	2.40	.70	.10	.30	.50	—.20	.65	7.20	1.50
7	.....	6.05	1.30	2.15	.70	.10	.85	.35	—.20	.50	3.20	1.40
8	.....	4.35	1.30	1.85	.60	.90	1.00	.40	—.20	.50	2.35	1.25
9	.....	3.60	1.30	1.65	.50	1.30	10.25	.25	—.30	.40	1.70	1.20
10	.....	3.50	1.30	1.35	.30	1.10	6.85	.90	—.30	.30	1.40	1.10
11	.....	2.95	1.30	1.30	.30	1.05	3.55	.55	—.30	.30	1.15	1.00
12	.....	2.30	1.30	.50	.20	.70	2.40	.20	—.30	.15	.90	.90
13	.....	2.05	1.60	.40	.20	.45	2.45	.10	—.30	.10	.80	.90
14	.....	3.90	1.60	.15	.10	.35	1.90	.10	—.30	.10	.80	.80
15	.....	4.30	1.60	.10	.10	.30	1.40	.45	—.30	.10	.80	.70
16	.....	3.30	1.60	.10	.10	.30	1.10	.60	—.30	.10	.70	.60
17	.....	2.90	5.95	.10	.00	.30	1.00	.25	—.30	.10	.70	.50
18	.....	2.30	5.45	—.45	.00	.30	.90	.15	—.30	.10	.60	.50
19	.....	2.00	4.50	—.20	.00	.35	.80	.10	—.30	.00	.60	.50
20	.....	2.00	6.25	+.05	.00	.70	.55	.10	—.30	.00	.50	.50
21	.....	2.00	5.05	.10	.85	.65	.40	—.10	—.30	.00	.50	.40
22	.....	2.00	3.80	.10	1.15	.45	.40	+.50	—.30	—.10	.40	.40
23	.....	2.00	3.25	.10	.80	.30	.75	.45	—.30	—.10	.40	.40
24	.....	1.60	3.75	.10	.90	.20	.55	.20	—.30	—.20	.40	.40
25	4.80	1.35	3.90	.10	.90	.20	.40	.20	—.30	—.20	.40	.40
26	3.40	1.30	3.55	—.30	.75	1.80	.30	.35	—.30	—.20	.40	.30
27	2.60	1.30	3.40	—.60	.65	2.05	.20	.20	—.30	—.20	.40	.30
28	2.00	1.30	3.40	—.60	.75	1.45	.20	.20	—.30	—.20	.30	.20
29	1.65	1.30	3.55	—.60	.70	1.15	.20	.20	—.30	—.20	1.30	.20
30	1.50	.....	9.45	—.60	.60	1.85	.70	.20	12.30	—.20	5.35	.20
31	1.30	.....	8.80	.....	.60	.....	.70	.10	.....	.....	.....	.20

Dan River at Clarksville, Virginia.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	9.47	2.62	1.22	1.02	0.92	0.42	7.92	0.97	3.53
2	.....	.....	10.37	3.67	1.17	.92	.87	.40	8.97	1.02	4.82
3	.....	.....	9.52	4.42	1.07	.87	.82	.52	3.47	1.04	3.65
4	.....	.....	5.77	3.47	.97	.82	.77	1.37	1.72	1.47	2.55
5	.....	.....	3.99	2.38	1.47	.87	.75	1.52	1.47	2.62	2.17
6	.....	.....	3.37	2.26	2.12	1.02	.72	.97	1.32	6.92	2.05
7	8.95	.....	3.32	2.12	1.97	4.02	.70	2.97	1.25	4.97	1.97
8	7.42	.....	2.97	1.97	1.47	6.02	.67	1.82	1.17	2.47	1.89
9	5.75	.....	2.77	1.82	1.47	9.12	.65	1.47	1.07	2.17	1.80
10	5.42	.....	2.52	1.72	1.97	13.97	.65	.97	1.02	1.77	1.72
11	4.40	.....	2.51	1.67	1.82	14.07	.87	.82	1.02	1.57	1.62
12	3.42	.....	2.50	1.62	1.72	8.87	1.65	.62	.97	1.47	1.56
13	2.92	.....	2.45	1.57	1.67	5.62	1.77	.57	.95	1.57	1.51
14	3.70	.....	2.22	1.54	1.62	3.22	1.92	.55	.95	1.52	1.43
15	3.47	1.90	2.17	1.47	1.62	2.67	1.97	.57	1.02	1.50	1.53
16	3.32	1.87	2.12	1.02	1.60	2.47	2.12	.57	.97	1.48	1.72
17	2.97	2.45	2.07	.97	1.57	2.39	1.47	.62	.96	1.48	2.15
18	2.40	2.68	2.02	1.02	1.47	2.27	.97	.59	.92	1.25	1.97
19	2.22	2.80	1.97	1.12	1.37	2.17	.72	.57	.87	1.22	1.72
20	2.07	4.09	1.92	1.62	1.32	2.03	.67	.67	.87	1.19	1.65
21	1.92	4.52	1.85	2.18	1.47	1.85	.65	.92	.85	1.16	1.59
22	1.77	3.32	1.90	3.07	1.57	1.79	.62	1.47	.82	1.16	1.52
23	1.97	2.72	1.90	4.37	1.72	1.70	.62	1.75	.89	1.15	1.45
24	2.10	2.49	1.82	3.17	2.47	1.57	.62	.72	.92	1.14	1.39
25	2.17	2.72	1.90	2.17	3.02	1.42	.59	.57	.97	1.13	1.35
26	2.07	2.80	2.47	1.50	3.53	1.35	.67	.52	.94	1.12	1.31
27	1.96	2.47	2.40	2.32	3.67	1.17	.77	.47	.92	1.11	1.29
28	1.99	2.27	2.00	2.97	2.67	1.12	.62	.45	.92	1.10	1.27
29	2.17	2.27	1.90	2.32	2.02	1.07	.57	1.72	.92	1.32	1.24
30	.....	3.39	1.77	1.82	1.52	1.02	.47	5.47	.91	2.02	1.22
31	.....	7.89	.....	1.27	.....	.97	.42	.....	.94	.....	1.22

Staunton River at Clarksville, Virginia.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	8.94	2.00	0.69	0.49	0.39	−0.11	7.45	0.44	3.01
2	.....	.....	9.84	3.14	.64	.39	.34	− .11	8.50	.49	4.31
3	.....	.....	8.99	3.89	.54	.34	.29	− .01	2.96	.51	3.14
4	.....	.....	5.24	2.94	.44	.29	.24	+ .84	1.20	.94	2.03
5	.....	.....	3.46	1.85	.94	.34	.22	.99	.94	2.10	1.65
6	.....	.....	2.84	1.73	1.59	.49	.19	.44	.79	6.42	1.53
7	8.42	.....	2.79	1.59	1.44	4.54	.17	2.47	.72	2.37	1.45
8	6.89	.....	2.44	1.44	.94	6.84	.14	1.30	.64	1.95	1.37
9	5.16	.....	2.24	1.29	.94	10.54	.12	.94	.54	1.54	1.27
10	4.84	.....	1.99	1.19	1.44	13.94	.12	.44	.49	1.24	1.19
11	3.85	.....	1.98	1.14	1.29	13.44	.34	.29	.49	1.04	1.09
12	2.86	.....	1.97	1.09	1.19	8.39	1.12	.09	.44	.94	1.03
13	2.37	.....	1.92	1.04	1.14	5.14	1.24	.04	.42	1.04	.98
14	3.16	.....	1.69	1.01	1.09	2.74	1.39	.02	.42	.99	.92
15	2.94	1.37	1.64	.94	1.09	2.06	1.44	.04	.49	.98	1.03
16	2.78	1.33	1.59	.49	1.07	1.94	1.64	.04	.44	.95	1.20
17	2.41	1.92	1.54	.44	1.04	1.86	.97	.09	.43	.94	1.63
18	1.86	2.15	1.49	.49	.94	1.74	.46	.06	.39	.72	1.35
19	1.68	2.27	1.44	.59	.84	1.64	.20	.04	.34	.69	1.20
20	1.53	3.56	1.39	1.09	.79	1.44	.14	.16	.34	.66	1.13
21	1.38	3.99	1.32	1.65	.94	1.32	.12	.40	.32	.63	1.07
22	1.33	2.79	1.37	2.59	1.04	1.26	.09	.96	.29	.63	.90
23	1.43	2.19	1.37	3.84	1.19	1.27	.09	1.24	.36	.62	.92
24	1.56	1.96	1.29	2.64	1.94	1.04	.09	.19	.39	.61	.86
25	1.64	2.19	1.37	1.64	2.49	.89	.06	.04	.44	.60	82
26	1.54	2.27	1.94	.97	2.94	.82	.14	− .01	.41	.59	.78
27	1.43	1.96	1.86	1.79	3.14	.64	.24	−1.06	.39	.58	.76
28	1.46	1.72	1.47	2.44	1.14	.59	.09	− .08	.39	.57	.74
29	1.54	1.73	1.37	1.79	.49	.54	.04	+1.20	.39	.79	.71
30	.....	2.86	1.24	1.29	− .01	.49	− .06	4.99	.38	1.50	.69
31	.....	7.36	.....	.74	.....	.44	− .11	.....	.41	.....	.69

Roanoke River[1] *at Clarksville, Virginia, for 1893.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.1	.....	2.6	1.0	1.6	1.4	2.0	1.5	9.0	2.2	2.1	1.9
2	3.9	.....	2.3	1.0	1.5	1.7	1.9	1.7	11.3	2.8	2.0	1.8
3	2.7	.....	3.0	1.0	9.0	1.5	2.0	2.0	9.0	2.5	1.9	2.0
4	2.0	.....	3.2	1.0	13.0	1.5	1.6	2.8	3.8	7.7	1.9	2.5
5	1.5	.....	3.3	1.4	12.5	1.5	1.5	2.0	2.8	8.0	1.9	2.4
6	1.1	.....	2.5	1.3	4.5	1.5	1.0	.8	1.9	4.5	1.8	2.4
7	1.1	.....	2.2	1.2	4.2	1.6	.7	.5	1.5	2.6	1.8	2.3
8	1.0	1.8	2.0	1.1	2.8	1.4	.6	.4	1.5	2.2	2.0	2.3
9	1.0	1.6	2.2	1.0	2.5	1.0	.8	.2	1.4	1.9	1.9	2.2
10	1.0	4.5	2.0	1.0	2.2	.9	1.0	.1	3.0	1.7	1.8	2.0
11	1.0	7.4	2.0	1.0	2.0	.8	.6	.1	6.5	1.6	1.8	1.9
12	1.0	7.8	1.9	1.0	1.7	.7	.5	.1	9.0	1.5	1.7	1.8
13	1.0	9.0	1.8	1.0	1.6	.9	.4	.3	11.0	6.0	1.6	1.7
14	1.0	10.5	2.0	1.3	1.5	2.2	.4	.3	13.5	8.8	1.7	1.6
15	1.0	6.5	1.8	1.3	1.8	4.4	.4	.2	11.1	8.7	2.0	1.6
16	1.0	4.5	1.6	1.1	3.0	3.0	.4	.1	3.5	4.0	2.0	3.6
17	2.5	7.7	1.5	1.1	1.9	2.1	.3	.0	2.5	2.8	1.8	3.5
18	3.0	9.0	1.5	1.0	1.5	1.9	.5	.0	2.1	2.3	1.6	2.4
19	.....	7.4	1.4	1.0	1.3	1.7	.5	.1	1.9	2.0	1.6	2.1
20	.....	5.0	1.4	1.0	1.1	1.2	.3	.0	1.7	1.8	1.5	1.9
21	.....	3.0	1.4	.9	1.1	1.0	.8	− .1	1.6	7.3	1.7	1.8
22	.....	2.7	1.4	.9	1.1	1.0	.5	− .3	1.4	9.9	1.8	1.6
23	.....	2.5	1.3	.9	1.1	1.6	.4	.0	1.4	10.1	1.8	1.6
24	.....	2.2	1.3	.9	1.1	1.1	.3	+2.5	1.3	10.5	1.6	1.5
25	.....	2.0	1.3	.9	1.0	.9	.2	1.0	1.2	5.8	1.5	1.5
26	.....	1.9	1.3	1.0	1.0	.8	.1	.7	4.0	3.8	1.5	1.5
27	.....	1.8	1.3	2.7	1.0	.8	.1	.6	3.5	3.3	1.6	1.4
28	.....	2.4	1.2	2.8	1.9	.7	.1	5.0	2.6	3.0	3.2	1.4
29	.....	.....	1.2	2.3	2.8	1.3	0.0	9.0	1.8	2.7	3.0	1.4
30	.....	.....	1.2	2.0	2.1	2.6	− .1	11.0	1.5	2.4	2.2	2.1
31	.....	.....	1.2	.....	1.6	.....	+ .5	7.6	.....	2.3	.....	2.2

[1] Record kept by United States Weather Bureau.

Roanoke River[1] *at Clarksville, Virginia, for 1894.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1	1.8	2.4	5.4	1.7	1.3	1.1	1.1	1.3
2	1.7	2.0	5.8	1.7	1.3	1.0	2.1	1.5
3	1.6	4.4	5.4	1.7	1.3	.9	2.0	1.7
4	1.5	7.0	4.0	1.6	2.0	.8	1.8	1.3
5	1.5	6.9	3.2	1.5	3.1	.8	1.0	1.2
6	1.8	3.4	3.0	1.5	3.4	.8	.9	.7
7	3.2	3.0	2.8	1.4	2.2	.8	1.2	.5
8	3.1	3.2	2.6	1.4	1.6	1.0	1.1	.3
9	2.8	3.5	2.4	1.4	1.4	1.0	.6	.3
10	2.7	3.4	2.3	2.0	1.3	.8	.4	.5
11	3.3	2.6	2.2	2.3	1.2	.7	.4	.7
12	3.0	4.0	2.1	2.0	1.3	.7	.3	1.1
13	2.5	6.2	2.0	1.7	1.3	.6	.3	1.0
14	2.1	6.2	1.9	1.5	1.2	.6	.2	.8
15	2.0	5.6	1.8	1.5	1.1	.6	.2	1.1
16	1.9	4.5	1.8	1.4	1.1	.5	.2	.9
17	1.8	3.5	2.0	1.4	1.1	.5	.2	.8
18	1.7	2.9	2.1	1.4	1.3	.6	0.0	.7
19	1.6	2.7	2.1	1.4	2.0	.7	— .2	.5
20	1.6	2.4	1.9	1.4	4.6	.9	— .1	.4
21	1.6	2.9	1.9	2.0	2.4	.8	+ .3	.3
22	1.7	3.1	1.9	1.8	1.7	.7	.9	.2
23	1.7	2.8	1.8	1.5	1.5	.6	2.0	.1
24	1.7	2.4	1.9	1.4	1.5	.6	1.5	.1
25	1.6	2.4	2.0	1.3	1.4	.6	.9	.1
26	1.7	2.8	1.9	1.3	1.2	.5	.7	1.6
27	1.7	4.3	1.7	1.2	1.1	.5	.6	1.4
28	1.9	4.7	1.6	1.2	1.1	.6	.5	.7
29	4.0	.....	1.7	1.4	1.1	.7	.5	.5
30	4.1	.....	1.7	1.3	1.1	.9	1.1	.4
31	3.3	.....	1.6	.....	1.2	.....	1.3	.3

Roanoke River[1] *at Clarksville, Virginia, for 1895.*

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Day.	Mar.	Apr.	May.	June.	July.	Aug.
1	4.0	1.7	5.9	1.5	2.5	0.8	17	2.5	3.0	2.0	1.3	1.6	1.0
2	6.7	1.8	4.7	1.4	3.5	.7	18	2.2	3.5	2.7	1.2	1.1	1.4
3	9.0	2.0	3.5	1.3	2.7	.7	19	2.1	2.8	2.1	1.1	.8	1.3
4	4.4	1.8	3.0	1.2	1.7	.6	20	4.0	2.0	2.2	1.1	.8	1.0
5	3.1	1.5	2.5	1.4	1.1	6	21	5.9	1.9	3.0	.9	.9	1.4
6	2.5	1.5	2.2	1.7	.9	.9	22	4.3	1.8	4.2	.9	.9	1.2
7	3.2	3.9	2.4	2.0	.9	1.0	23	3.5	1.7	3.0	.9	1.3	1.0
8	4.7	8.7	2.7	1.3	.9	.9	24	3.1	1.6	2.5	.9	1.5	.7
9	3.3	9.6	2.1	1.2	1.0	.9	25	2.6	1.5	2.9	1.0	3.3	.6
10	2.5	4.5	1.9	1.2	1.1	1.4	26	2.5	1.5	5.0	1.2	4.4	.6
11	2.6	2.9	1.8	1.4	1.2	1.0	27	2.3	7.4	4.0	2 0	2.5	.7
12	2.7	2.6	2.6	1.6	1.0	.8	28	2.1	6.5	2.5	1.8	1.8	.6
13	3.1	2.5	2.2	1.7	.9	.9	29	1.9	7.7	2.1	1.5	1.0	.6
14	3.4	2.3	1.9	1.8	.9	.8	30	1.7	7.9	1.8	1.2	.9	.5
15	3.2	2.1	1.6	1.6	1.1	.7	31	1.6	.....	1.7	.....	.9	.5
16	2.9	2.0	1.5	1.4	2.4	.6							

[1] Record kept by United States Weather Bureau.

Roanoke River[1] *at Clarksville, Virginia, for 1896.*

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1	.....	2.0	9.0	3.8	1.3	0.8	0.7
2	.....	1.5	9.1	3.7	1.0	.8	.7
3	.....	1.3	4.5	3.3	.9	.7	.7
4	.....	1.2	3.3	2.5	1.2	.7	.6
5	.....	1.1	2.5	1.8	2.0	2.7	.6
6	.....	1.0	2.3	1.5	1.5	4.3	.6
7	7.4	1.0	2.0	1.3	1.4	5.0	.5
8	7.5	1.0	1.9	1.2	1.3	8.0	.5
9	5.0	1.0	1.8	1.1	1.8	12.5	.5
10	.....	1.0	1.8	1.0	1.5	13.8	.4
11	.....	1.0	1.6	1.0	1.3	11.0	1.4
12	.....	1.5	1.5	.9	1.2	5.5	.7
13	.....	1.4	1.4	.9	1.5	4.0	.6
14	.....	1.3	1.4	.8	1.3	2.7	.5
15	.....	1.2	1.4	.8	1.2	2.4	.5
16	.....	1.6	1.4	.8	1.3	2.2	2.0
17	.....	1.7	1.3	.8	1.5	2.5	1.0
18	.....	2.0	1.3	.8	1.4	1.8	.9
19	.....	3.0	1.3	.8	1.2	1.4	.7
20	.....	3.9	1.3	2.7	1.2	1.3	.5
21	.....	2.7	1.2	3.5	1.1	1.2	.5
22	.....	2.0	1.2	2.9	1.8	1.2	.5
23	.....	1.8	1.2	2.5	1.6	1.0	.5
24	.....	1.9	1.2	1.9	1.5	1.0	.5
25	.....	1.9	2.0	1.5	1.9	1.0	.5
26	.....	1.9	1.8	1.8	3.0	.9	.4
27	.....	1.8	1.4	1.6	2.6	.9	.4
28	.....	1.8	1.2	1.5	2.4	.8	.4
29	.....	2.5	1.1	1.5	2.1	.8	.4
30	.....	4.0	4.8	1.5	1.3	.8	.4
31	.....	7.8	.....	1.5	.....	.8	.4

Roanoke River at Neal, North Carolina.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.56	1.65	2.80	2.60	5.40	17	.....	3.50	4.30	3.60	6.20	13.30
2	.....	3.90	1.30	a21.80	2.50	15.85	18	.....	2.70	4.64	3.40	5.80	13.30
3	.....	4.15	1.00	23.00	2.40	19.70	19	.....	5.30	3.50	3.10	5.12	11.70
4	.....	3.70	1.00	25.10	2.40	17.70	20	.....	5.20	2.50	2.90	4.70	10.00
5	.....	3.40	1.24	24.20	2.90	14.80	21	.....	3.90	2.80	2.70	4.40	8.80
6	.....	3.00	1.30	20.80	3.10	12.50	22	.....	2.90	2.60	2.50	4.20	7.80
7	.....	2.90	1.30	17.00	17.00	11.00	23	.....	2.40	2.80	2.40	4.00	7.00
8	.....	2.80	5.05	13.70	20.30	10.30	24	.....	2.00	3.30	2.50	3.80	6.40
9	.....	2.50	8.90	11.10	18.50	9.90	25	.....	2.03	3.30	2.60	3.70	5.90
10	.....	2.20	7.30	8.90	14.90	9.20	26	.....	2.25	2.60	2.60	3.60	5.40
11	.....	2.10	5.00	7.10	11.80	8.40	27	7.05	2.50	8.10	2.70	3.60	5.00
12	.....	2.30	3.30	5.60	9.70	7.60	28	5.09	2.20	1.80	2.70	3.50	4.60
13	.....	2.90	2.20	4.50	8.20	6.90	29	4.08	2.90	1.60	2.80	3.50	4.10
14	.....	5.20	1.80	4.20	7.10	6.30	30	4.24	2.70	1.90	2.72	3.80	3.90
15	.....	5.60	1.56	4.10	6.30	6.00	31	3.80	2.20	.....	2.60	.....	4.00
16	.....	4.60	2.10	3.80	6.10	8.30							

a Rise began about 10 a. m. and continued at rate of about 2 feet per hour for some time.

Tar River at Tarboro, North Carolina.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.30	1.00	2.82	0.89	3.87	17	.....	1.25	4.50	1.98	2.45	12.73
2	.....	1.00	.60	3.55	.96	4.34	18	.....	1.28	4.35	1.50	1.95	13.82
3	.....	.90	.45	4.20	1.20	4.85	19	.....	1.00	4.20	1.00	1.63	14.50
4	.....	1.20	.80	2.95	1.05	4.90	20	.....	.73	4.60	1.15	1.61	13.50
5	.....	1.46	.51	2.18	1.07	4.50	21	.....	.50	3.52	.90	1.50	12.20
6	.....	3.48	.30	1.90	2.15	4.70	22	.....	.65	2.10	.31	1.42	10.40
7	.....	2.87	.35	1.50	2.76	5.00	23	.....	.62	5.85	.69	1.30	8.20
8	.....	1.95	.60	1.20	3.72	5.80	24	.....	.05	7.30	.85	1.44	6.44
9	.....	1.45	.35	1.05	3.13	6.50	25	.....	.70	6.40	1.28	1.12	5.40
10	.....	1.00	.23	.85	2.59	6.72	26	3.56	1.20	4.60	1.12	1.05	4.75
11	.....	.82	.20	.90	2.10	6.10	27	3.00	1.30	3.60	1.32	1.02	4.20
12	.....	.50	.22	.81	1.71	5.33	28	2.68	1.40	2.85	1.00	1.00	4.05
13	.....	1.78	.12	1.05	2.62	4.64	29	2.25	1.60	2.58	.89	1.02	3.80
14	.....	1.92	.10	1.42	4.05	4.07	30	2.00	1.48	2.72	.80	1.45	3.50
15	.....	1.85	.18	1.70	3.20	3.98	31	1.76	1.10	.....	.58	.....	3.20
16	.....	1.53	3.45	2.00	2.62	9.75							

[1] Record kept by United States Weather Bureau.

Neuse River at Selma, North Carolina.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.00	0.30	5.00	0.60	3.70	17	.....	0.90	0.06	0.50	0.70	9.00
2	.....	2.00	.30	7.20	.60	3.50	18	.....	.90	.05	.40	.70	8.60
3	.....	2.00	.35	2.30	.60	3.00	19	.....	1.10	.00	.40	.60	5.50
4	.....	1.90	.40	.90	.40	2.80	20	.....	1.00	.00	.30	.60	4.60
5	.....	1.20	.30	.50	1.20	2.60	21	.....	1.00	1.04	.40	.60	3.50
6	.....	1.00	.30	.50	4.80	2.50	22	.....	.50	.04	.60	.50	3.00
7	.....	1.00	.30	.30	4.40	3.00	23	.....	.40	5.04	.90	.50	2.80
8	.....	1.08	.60	.20	2.30	4.00	24	.....	.50	1.07	.70	.50	2.00
9	.....	.90	.50	.20	1.50	3.80	25	.....	2.10	.07	.50	.50	1.90
10	.....	5.05	.30	.10	1.20	3.50	26	.....	2.00	.07	.40	.50	1.80
11	.....	5.50	.20	.20	.80	2.60	27	.....	1.10	.40	.30	.50	1.50
12	.....	5.50	.20	.50	.80	2.00	28	.....	1.00	.30	.30	.50	1.50
13	.....	2.25	.01	.70	1.30	2.00	29	1.10	1.00	.10	.30	.50	1.40
14	.....	1.50	.01	1.70	1.20	2.00	30	1.00	.50	1.50	.40	.70	1.30
15	.....	1.20	.01	1.00	.90	3.00	31	1.00	.30	.....	.40	.....	1.20
16	.....	.80	.01	.60	.80	7.30							

Cape Fear River at Fayetteville, North Carolina.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	18.00	6.50	9.00	7.50	3.70	4.00	7.00	3.30	1.30	31.00	2.50	6.00
2	18.90	6.50	10.40	9.50	5.00	3.20	5.30	4.30	1.10	26.80	2.70	15.40
3	11.40	7.90	9.30	22.50	8.00	2.70	4.00	4.00	1.00	19.50	2.70	14.00
4	8.00	27.70	7.60	19.40	12.80	4.00	3.50	3.30	.80	12.90	3.00	12.40
5	6.50	31.00	6.80	13.00	10.40	19.00	3.50	3.00	1.50	7.80	4.30	10.40
6	5.70	30.00	6.00	9.80	8.30	20.00	5.90	3.00	3.00	4.90	17.00	9.50
7	4.60	45.40	5.80	8.00	6.00	14.00	4.40	2.80	8.50	4.20	19.00	9.60
8	4.40	48.00	5.80	6.80	4.50	10.00	15.00	2.60	9.50	3.60	14.30	13.50
9	4.60	45.00	5.40	6.00	4.40	8.00	34.80	2.30	5.50	3.20	10.40	14.50
10	4.60	42.40	5.40	5.40	3.90	6.20	47.50	2.00	4.00	3.00	7.70	13.60
11	4.70	36.00	5.50	5.20	3.50	6.00	49.50	2.00	3.30	2.70	6.00	11.70
12	4.40	30.40	7.80	5.50	3.20	6.00	47.00	1.90	2.50	2.70	4.80	9.50
13	4.20	19.00	11.00	5.50	2.80	5.00	41.00	2.70	2.00	2.70	4.60	8.20
14	4.00	16.20	10.00	5.00	2.80	7.00	30.30	4.00	1.50	3.00	4.50	7.00
15	4.10	17.40	8.60	4.90	2.60	10.90	19.00	3.40	1.40	3.30	4.50	7.50
16	4.00	16.00	7.20	5.00	2.50	8.50	14.40	3.70	1.20	3.20	4.80	9.40
17	5.00	13.40	7.50	4.90	2.50	5.70	9.50	3.70	1.00	3.00	4.20	14.00
18	9.00	11.60	8.00	4.70	2.10	4.60	9.30	3.00	1.50	2.90	4.00	12.30
19	6.00	10.50	7.80	4.50	2.40	6.00	9.00	2.60	1.90	2.60	4.00	9.00
20	1.40	10.60	8.50	4.20	2.30	5.30	8.70	2.50	3.00	2.40	3.80	9.00
21	15.00	9.80	10.50	4.00	3.50	6.40	8.90	2.50	2.50	2.10	3.60	8.20
22	22.20	9.00	9.60	3.80	4.10	5.00	8.30	2.10	1.50	2.20	3.50	7.00
23	20.00	8.00	7.80	3.60	8.17	4.30	7.90	2.70	6.00	2.30	3.20	6.90
24	15.00	7.80	6.80	3.50	11.40	4.50	7.20	2.00	6.80	2.70	3.10	6.30
25	15.60	7.80	6.50	4.00	17.40	6.40	7.50	2.40	5.00	4.40	3.00	5.40
26	11.00	7.70	6.60	4.60	12.00	7.80	7.00	4.00	3.90	4.10	3.00	4.60
27	26.20	7.40	7.00	7.00	9.50	8.60	5.20	3.70	3.20	3.50	3.00	5.00
28	22.00	7.30	6.30	5.50	8.00	6.00	4.30	2.70	2.90	3.00	3.30	4.90
29	29.40	7.90	6.20	4.90	7.20	10.80	3.70	2.00	3.50	2.80	3.20	4.80
30	18.10	.....	5.80	4.10	6.00	8.90	3.60	1.90	8.00	2.50	3.50	4.90
31	17.00	.....	5.30	.....	5.00	.....	3.40	1.40	.....	2.50	.....	5.00

Yadkin River at Norwood, North Carolina.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1	1.00	7.40	1.30	1.50	12	1.20	1.20	1.70	1.70	23	1.20	1.20	1.40	1.80
2	1.00	3.40	1.30	2.70	13	1.20	1.20	2.20	1.30	24	1.30	1.20	1.40	1.80
3	1.00	2.30	1.30	2.70	14	1.20	1.20	1.30	1.60	25	1.20	1.30	1.40	1.70
4	.90	1.80	1.40	2.30	15	1.30	1.30	1.90	1.90	26	1.20	1.30	1.40	1.70
5	.90	1.60	3.10	2.30	16	1.20	1.30	1.70	2.50	27	1.10	1.30	1.40	1.70
6	2.50	1.50	6.00	2.20	17	1.30	1.20	1.60	3.80	28	1.00	1.30	1.40	1.70
7	3.30	1.40	3.40	2.30	18	1.30	1.20	1.50	2.90	29	1.20	1.20	1.50	1.60
8	2.10	1.40	2.50	2.40	19	1.20	1.20	1.50	2.30	30	1.30	1.20	1.70	1.60
9	1.65	1.30	2.20	2.20	20	1.20	1.10	1.50	2.10	31	.....	1.20	.....	1.70
10	1.45	1.30	2.10	2.10	21	1.10	1.10	1.50	2.00	.....	.....	.....	.....	.....
11	1.30	1.20	1.90	1.90	22	1.10	1.10	1.50	1.90	.....	.....	.....	.....	.....

Yadkin River at Salisbury, North Carolina.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.60	2.00	2.50	2.50	1.80	1.50	1.80	2.00	1.40	8.40	1.68	6.70
2	3.00	2.00	2.20	8.00	1.80	1.50	1.60	1.90	1.40	3.70	1.70	4.10
3	2.40	5.70	2.70	7.30	2.10	1.80	1.60	1.90	1.40	2.20	1.72	3.70
4	2.20	6.70	1.80	4.00	2.90	3.90	2.60	1.70	1.40	2.50	.....	2.80
5	1.80	4.90	2.00	3.10	2.30	3.70	2.70	1.70	1.50	1.80	5.80	2.50
6	1.60	5.30	2.00	2.60	2.20	2.50	2.80	1.60	4.50	1.70	6.78	2.55
7	1.60	7.00	1.90	2.50	2.00	2.20	4.50	1.60	2.70	1.70	3.60	2.53
8	1.90	5.00	1.90	2.40	1.90	2.00	4.90	1.60	2.20	1.60	3.50	2.52
9	3.70	5.00	1.90	2.20	1.90	2.00	12.90	1.50	1.90	1.60	2.50	2.30
10	3.60	4.70	1.90	2.20	1.90	1.90	a15.00	2.00	1.60	1.60	2.30	2.27
11	3.40	3.60	2.00	2.20	1.90	2.20	10.00	2.00	1.50	1.60	2.20	2.26
12	2.60	3.00	2.20	2.10	1.90	1.80	9.80	1.90	1.50	1.62	2.10	2.26
13	2.10	2.70	2.40	2.00	1.80	1.80	7.90	1.80	2.00	1.66	2.15	2.25
14	1.70	3.30	2.10	2.00	1.70	1.80	4.90	1.60	1.75	1.64	2.00	2.23
15	1.70	3.10	2.00	2.00	1.70	1.70	4.00	1.60	1.60	1.70	2.00	2.30
16	1.70	2.80	1.80	2.00	1.70	1.60	3.70	2.50	1.50	1.70	2.00	5.00
17	1.90	2.50	2.00	2.00	1.70	1.60	2.80	2.20	1.60	1.68	1.98	3.55
18	2.20	2.30	2.00	2.00	1.70	1.80	2.40	2.90	1.60	1.65	1.95	3.40
19	2.10	2.20	1.90	2.10	1.60	1.80	2.40	2.70	1.60	1.50	1.92	2.95
20	2.00	2.10	2.20	2.00	1.60	1.80	2.20	2.50	1.50	1.50	1.90	3.90
21	1.90	2.00	2.60	2.00	1.50	1.70	2.20	1.90	1.50	1.50	1.90	3.70
22	1.80	1.80	2.20	2.00	1.80	1.70	2.30	1.90	1.50	1.48	1.90	3.33
23	2.50	2.10	2.10	2.00	1.80	1.60	2.50	1.50	1.70	1.48	1.89	2.30
24	4.30	2.20	2.10	1.90	1.80	1.80	2.30	1.50	1.60	1.60	1.88	2.20
25	3.70	2.10	2.50	1.90	1.70	2.10	2.20	1.50	1.50	1.76	1.88	2.13
26	3.20	2.10	2.40	2.00	2.00	2.80	2.00	1.60	1.50	1.67	1.88	2.12
27	2.60	2.10	2.20	2.00	2.00	2.60	1.90	1.60	1.46	1.65	1.90	2.10
28	2.40	2.20	2.10	1.90	1.80	2.20	1.90	1.50	1.45	1.65	1.90	2.00
29	2.20	2.30	2.00	1.90	1.70	2.10	2.20	1.50	1.50	1.65	2.70	2.00
30	2.10	.....	2.10	1.90	1.70	1.90	1.90	1.50	8.60	1.65	6.30	2.08
31	2.00	.....	2.60	.....	1.60	.....	1.90	1.40	.....	1.68	.....	2.07

a July 10 river rose 14.90 above low-water mark.

Catawba River at Rockhill, South Carolina.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.30	2.10	2.30	2.10	1.70	1.50	1.70	2.00	1.50	3.90	1.60	5.50
2	2.90	2.10	2.20	2.70	1.80	1.90	1.60	1.90	1.50	2.60	1.70	4.30
3	2.40	3.60	2.10	5.80	3.80	2.20	2.00	2.00	1.50	2.00	1.70	3.10
4	2.20	4.90	2.10	3.50	4.30	2.50	2.60	1.90	1.50	1.70	1.70	2.60
5	2.00	3.50	2.00	2.80	2.90	3.20	2.00	1.90	2.10	1.60	3.30	2.40
6	1.90	6.25	2.00	2.50	2.50	2.60	4.50	2.00	2.10	1.60	5.40	2.30
7	1.80	6.60	2.00	2.30	2.30	2.10	5.20	1.90	2.90	1.60	3.90	2.40
8	1.80	4.90	2.00	2.20	2.10	1.90	7.37	1.80	2.20	1.50	2.60	2.30
9	2.00	5.70	1.90	2.10	2.00	1.80	12.22	1.80	1.90	1.50	2.40	2.20
10	1.90	5.30	1.90	2.10	2.00	2.20	15.20	1.70	1.70	1.50	2.20	2.10
11	1.90	4.00	1.90	2.00	1.90	1.80	10.65	1.70	1.60	1.60	2.00	2.00
12	1.90	3.20	2.10	2.00	1.80	1.70	7.90	1.70	1.60	1.50	1.90	1.90
13	1.80	2.80	2.10	2.00	1.80	1.70	6.30	1.80	1.50	1.50	2.50	1.90
14	1.80	2.90	2.00	1.90	1.80	1.60	4.40	1.70	2.00	1.50	2.20	1.90
15	1.80	2.80	2.00	1.90	1.70	1.60	3.40	2.10	1.70	1.60	2.20	1.90
16	1.80	2.70	1.90	1.90	1.70	1.60	3.10	2.00	1.60	1.60	2.10	3.20
17	2.10	2.60	1.90	1.90	1.70	1.60	2.80	1.90	1.60	1.60	1.90	3.40
18	2.40	2.40	1.90	1.90	1.70	1.60	2.60	2.00	1.60	1.50	1.80	2.70
19	2.20	2.40	1.90	1.80	1.70	1.80	2.40	2.00	1.60	1.50	1.80	2.30
20	2.00	2.30	2.10	1.80	1.70	2.00	2.70	1.80	1.60	1.50	1.80	2.20
21	2.00	2.30	2.00	1.80	1.60	2.00	2.50	1.70	1.50	1.50	1.80	2.10
22	1.90	2.20	2.10	1.80	1.60	1.90	2.50	1.60	1.60	1.50	1.70	2.00
23	2.60	2.10	2.00	1.80	1.60	2.10	2.20	1.60	1.60	1.50	1.70	2.00
24	3.80	2.10	2.00	1.80	1.60	1.90	2.30	1.60	1.60	1.60	1.70	1.90
25	4.50	2.20	2.00	1.80	2.60	1.90	2.20	1.60	1.60	1.60	1.70	1.80
26	3.80	2.10	2.20	1.80	1.90	2.10	2.10	1.60	1.60	1.60	1.70	1.80
27	2.90	2.10	2.10	1.80	1.80	2.00	2.10	1.60	1.50	1.60	1.70	1.80
28	2.60	2.10	2.00	1.80	1.90	2.00	2.40	1.60	1.50	1.60	1.70	1.80
29	2.40	2.30	2.00	1.70	1.80	2.00	2.40	1.60	1.60	1.50	1.90	1.80
30	2.20	.....	1.90	1.70	1.70	1.90	2.30	1.50	4.30	1.50	2.20	1.80
31	2.20	.....	2.00	.....	1.60	.....	2.10	1.50	.....	1.60	.....	1.80

Catawba River at Catawba, North Carolina.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.25	1.65	2.45	1.68	5.58	17	2.98	2.08	1.82	1.48	1.92	3.28
2	.....	2.25	1.85	2.25	1.65	5.32	18	2.92	1.88	1.62	1.48	1.92	2.95
3	.....	2.22	1.48	1.92	1.58	3.32	19	2.78	1.82	1.52	1.48	1.92	2.95
4	3.05	2.28	1.45	1.65	1.88	2.65	20	2.75	1.68	1.53	1.48	1.92	2.42
5	2.95	2.15	3.32	1.52	7.38	2.65	21	2.62	1.68	1.52	1.58	1.92	2.22
6	4.32	2.05	2.32	1.58	3.92	2.82	22	2.72	1.62	1.55	1.50	1.88	2.05
7	3.82	1.98	2.32	1.58	3.35	2.32	23	2.72	1.65	1.52	1.52	1.85	2.00
8	5.75	1.92	1.72	1.55	2.32	2.18	24	2.62	1.68	1.52	1.58	1.85	2.12
9	5.00	1.92	1.62	1.52	2.12	2.12	25	2.52	1.65	1.52	1.58	1.78	1.98
10	7.72	1.95	1.52	1.52	1.95	2.10	26	2.48	1.62	1.48	1.52	1.75	1.95
11	7.48	2.02	1.52	1.52	1.88	1.98	27	2.42	1.62	1.48	1.52	1.72	1.85
12	5.95	1.98	1.72	1.55	1.88	1.98	28	2.92	1.52	1.52	1.52	1.72	1.90
13	5.25	1.92	1.95	1.55	1.85	1.98	29	2.48	1.52	1.55	1.55	2.98	1.90
14	4.38	1.88	1.68	1.68	1.82	1.95	30	2.35	1.65	4.02	1.55	7.42	1.90
15	3.58	2.02	1.62	1.62	1.92	3.78	31	2.28	1.85	.....	1.68	.....	1.90
16	3.32	2.15	1.62	1.52	1.92	3.68							

Broad River at Gaffney, South Carolina.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	0.43	0.10	0.81	0.47	2.63	17	0.59	0.68	0.30	0.29	0.65	1.45
2	.....	.41	.11	.44	.28	1.60	18	.53	.49	.35	.23	.59	1.21
3	.....	.60	.84	.38	.40	1.02	19	.52	.30	.23	.20	.53	1.09
4	.....	.67	.46	.30	.40	.92	20	.51	.22	.10	.25	.72	1.12
5	.....	.38	.63	.22	1.50	1.50	21	.50	.28	.10	.29	.79	1.11
6	.....	.28	.49	.35	5.82	1.11	22	.50	.23	.30	.27	.60	1.05
7	.....	.32	.40	.31	2.40	1.15	23	.49	.20	.25	.29	.65	.99
8	.....	.30	.41	.30	1.98	1.10	24	.50	.18	.18	.28	.71	.94
9	.....	.18	.40	.25	.92	1.30	25	.48	.21	.14	.32	.69	.91
10	2.52	.30	.14	.30	.68	.91	26	.55	.24	.19	.28	.66	1.01
11	5.88	.25	.20	.22	.62	.85	27	.53	.17	.12	.31	.68	.80
12	1.60	.33	.82	.15	.31	.83	28	1.64	.18	.05	.35	.69	.93
13	.83	.22	.29	.31	.75	.77	29	.78	.20	.19	.29	.45	.95
14	.81	.48	.20	.35	1.04	.99	30	.62	.10	1.64	.31	1.70	.92
15	.78	.50	.23	.37	1.84	1.15	31	.48	.14	.....	.30	.....	.89
16	.88	.36	.20	.30	1.75	2.05							

Broad River at Alston, South Carolina.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.61	1.50	8.35	2.71	8.46	17	4.83	2.13	1.99	2.60	3.07	6.01
2	.....	3.02	1.85	3.95	2.63	7.80	18	4.03	2.86	1.09	1.96	2.89	4.39
3	2.21	3.03	1.93	3.45	2.20	6.55	19	3.87	2.52	2.05	1.95	2.73	4.06
4	2.17	2.95	2.73	2.52	2.40	6.00	20	5.00	2.35	2.01	1.75	2.74	3.80
5	2.87	2.86	4.75	2.21	9.47	5.33	21	5.42	3.67	1.93	1.90	2.76	3.55
6	2.64	2.61	4.93	1.90	13.38	5.21	22	4.06	2.81	2.78	2.02	2.60	3.50
7	8.20	2.51	3.89	1.85	10.33	5.84	23	3.84	1.98	4.63	2.03	2.69	3.45
8	13.39	2.43	3.21	2.15	7.20	6.77	24	3.30	1.95	2.68	2.40	2.56	3.40
9	16.24	2.30	2.52	2.10	4.11	6.35	25	3.14	2.05	2.51	2.64	2.72	3.25
10	17.26	2.03	2.18	2.00	3.56	5.61	26	2.90	2.01	1.94	2.49	2.66	3.15
11	13.59	1.91	2.13	2.05	2.73	4.40	27	2.87	2.15	1.85	2.07	2.62	3.04
12	13.39	2.87	2.15	1.81	3.15	3.96	28	2.79	2.19	1.85	2.25	2.70	3.06
13	9.92	2.07	2.36	1.72	5.11	3.64	29	4.77	2.44	2.11	2.20	2.75	3.09
14	6.55	2.92	2.51	2.02	4.78	3.70	30	3.40	2.15	6.78	2.19	4.26	3.18
15	5.05	2.71	1.96	2.20	3.85	3.40	31	2.90	1.65	.....	2.26	.....	3.07
16	4.20	3.31	2.15	2.40	3.31	6.30							

Saluda River at Waterloo, South Carolina.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.90	4.00	3.70	8.30	17	.....	3.15	2.80	4.65	5.55
2	.....	3.50	3.50	2.60	(a)	18	.....	3.15	3.15	4.55	4.75
3	.....	2.80	3.75	4.00	(a)	19	.....	3.70	2.20	4.50	5.15
4	.....	1.90	3.10	10.80	(a)	20	.....	3.00	3.20	4.45	4.15
5	.....	3.50	2.40	14.50	5.50	21	.....	2.20	3.15	4.45	4.35
6	.....	4.15	3.70	14.50	5.90	22	.....	4.25	3.00	3.80	4.65
7	.....	3.80	3.65	11.35	5.15	23	.....	4.35	3.60	3.80	4.00
8	.....	4.00	3.65	5.60	5.85	24	.....	4.00	4.10	4.30	4.55
9	.....	3.60	3.45	5.10	5.80	25	.....	3.30	3.90	4.35	3.85
10	.....	3.30	3.10	4.90	5.20	26	.....	3.20	2.45	4.25	3.20
11	.....	3.30	3.00	4.70	4.90	27	.....	2.90	3.80	4.30	2.85
12	.....	3.90	2.20	4.50	4.75	28	.....	2.30	3.80	4.25	3.80
13	.....	3.00	3.45	6.30	3.90	29	.....	5.40	3.55	5.20	4.35
14	.....	2.30	3.60	6.20	4.30	30	3.20	5.35	3.70	7.55	4.40
15	.....	3.65	3.60	4.85	8.40	31	2.20	.....	4.30	.....	4.35
16	.....	3.25	3.30	4.70	7.80						

a Ice on river; no readings December 2, 3, and 4.

Sarannah River near Calhoun Falls, South Carolina.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.00	2.00	2.20	5.60	17	2.10	2.00	1.95	3.00	3.40
2	.....	1.90	1.95	2.15	5.00	18	2.05	1.95	1.90	2.90	3.10
3	.....	1.85	1.90	2.05	4.95	19	2.05	1.90	1.85	2.65	3.00
4	2.40	1.80	1.95	3.00	5.15	20	2.00	1.85	1.80	2.40	2.85
5	2.30	1.95	1.90	5.65	5.00	21	1.90	1.80	1.80	2.25	2.80
6	2.15	3.85	1.85	7.15	4.05	22	1.85	1.70	1.75	2.35	2.75
7	2.10	3.00	1.90	4.75	3.50	23	1.80	2.50	1.75	2.30	2.65
8	2.00	2.40	1.75	3.00	3.75	24	1.75	2.40	2.15	2.30	2.60
9	2.05	2.40	1.70	2.60	3.05	25	1.75	2.35	2.05	2.30	2.55
10	2.10	2.25	1.70	2.45	3.20	26	2.00	2.25	2.00	2.25	2.50
11	2.05	2.20	2.00	2.30	2.85	27	2.45	2.00	1.95	2.25	2.45
12	2.00	2.30	2.25	2.20	2.60	28	2.00	1.90	1.90	2.20	2.40
13	1.95	2.15	2.50	5.60	2.45	29	1.95	1.95	1.85	2.30	2.40
14	2.80	2.10	2.40	4.10	2.55	30	1.90	2.00	1.95	2.95	2.40
15	3.10	2.05	2.15	3.60	3.85	31	1.85	.....	2.10	.....	2.35
16	2.30	2.00	2.00	3.25	3.20						

Oconee River[1] *at Dublin, Georgia, for 1894.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.6	2.8	11.2	3.8	1.9	0.2	1.4	5.0	4.9	1.0	2.0	1.3
2	3.6	2.5	11.8	3.5	1.8	.1	.6	6.8	3.9	.8	2.4	1.2
3	3.0	2.3	12.4	3.4	1.8	.0	.6	7.5	2.9	.6	3.0	1.1
4	2.6	2.3	12.8	3.4	1.5	.1	1.0	6.5	1.4	.4	6.1	1.0
5	1.9	2.5	13.0	3.5	1.4	.1	.8	5.0	1.0	.2	7.6	2.0
6	1.8	2.7	12.7	3.8	1.3	.2	.5	8.0	1.3	.1	6.0	2.4
7	2.0	2.9	11.0	3.8	1.1	.2	1.1	9.4	1.4	.2	3.6	2.4
8	2.0	2.7	8.0	3.7	1.0	.3	.9	10.0	1.1	.2	2.7	2.1
9	2.6	2.3	6.5	3.1	.9	.4	.3	11.0	1.8	1.1	2.0	1.9
10	3.8	2.2	6.0	2.9	.9	.4	1.4	13.2	1.8	6.5	1.7	1.7
11	4.4	2.2	5.5	3.0	.9	.4	4.9	14.9	1.4	8.6	1.5	2.2
12	5.0	4.0	5.5	4.0	1.5	.5	4.8	13.6	1.4	9.8	1.4	3.4
13	6.0	6.6	7.5	4.8	1.1	.6	3.3	7.8	1.3	12.5	1.3	6.0
14	6.6	7.8	8.6	4.1	.9	.7	1.8	4.0	1.0	14.8	1.3	8.1
15	6.9	9.7	8.9	3.3	.9	.7	.9	3.8	.9	13.8	1.4	9.5
16	6.5	11.3	8.6	2.9	1.5	.7	.8	2.0	.8	8.4	1.6	11.4
17	4.9	12.3	6.9	2.6	2.9	.7	.7	1.4	.6	3.4	1.8	12.9
18	5.0	13.7	6.4	2.5	2.5	.6	.4	1.4	.9	2.6	1.8	13.0
19	4.9	14.9	6.4	2.5	2.0	.3	1.1	4.9	2.2	2.0	1.6	10.5
20	4.3	14.3	6.3	2.8	1.6	.4	.3	6.0	4.5	1.8	1.6	5.4
21	3.5	12.7	5.9	4.5	1.9	.2	3.7	5.1	6.1	1.6	1.4	3.8
22	3.0	10.3	5.0	5.0	2.0	.1	5.0	3.3	6.6	1.4	1.5	3.2
23	3.2	8.4	4.4	4.9	1.5	.4	4.4	2.9	4.7	1.1	1.6	2.9
24	3.8	7.8	4.4	4.0	1.2	.8	3.8	2.3	2.1	1.0	1.5	2.5
25	3.7	8.0	5.1	3.0	1.0	.4	4.4	2.1	1.4	1.0	1.7	2.3
26	3.5	9.6	6.2	2.5	1.0	1.0	4.6	2.8	1.0	1.0	1.7	2.2
27	4.0	10.2	6.9	2.3	.9	2.9	3.8	4.4	1.0	1.0	1.8	2.7
28	3.9	10.8	6.0	2.0	.6	1.5	3.4	4.2	1.0	.9	1.7	3.9
29	3.4	.....	5.3	1.9	.5	.9	4.4	4.8	1.0	.9	1.4	5.0
30	3.0	.....	4.5	1.9	.5	1.5	3.4	4.2	1.0	.8	1.4	5.3
31	2.9	.....	4.0	.....	.4	.....	3.0	5.0	.....	.8	.....	4.3

[1] Record from United States Weather Bureau.

Oconee River[1] *at Dublin, Georgia, for 1895.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	3.4	14.2	5.4	5.2	9.6	6.8	2.5	0.9	2.3	0.3
2	3.2	14.5	5.2	5.0	10.3	4.4	5.0	.7	2.9	.3
3	3.2	14.8	5.0	5.2	10.5	3.6	6.5	.6	2.5	.2
4	3.5	14.2	6.8	5.8	8.7	3.0	6.9	.8	2.4	.1
5	3.8	13.4	7.8	5.7	6.6	2.8	6.4	6.5	5.7	.1
6	3.7	12.1	8.3	5.2	5.6	2.6	5.0	6.6	6.5	.0
7	3.4	11.3	8.5	4.6	5.2	2.4	3.8	4.0	7.0	.0
8	3.0	10.0	8.6	5.8	5.2	2.4	4.3	2.7	7.3	.1
9	3.0	9.2	9.9	8.4	4.9	3.0	7.4	3.5	8.3	.1
10	7.7	8.7	10.9	9.2	4.7	2.3	8.7	3.8	9.2	.1
11	10.4	7.8	12.0	10.3	6.4	2.1	9.5	2.9	7.5	.5
12	11.9	7.1	13.1	10.1	6.1	2.0	10.5	2.3	4.3	.4
13	15.5	7.8	13.1	10.2	6.0	1.9	11.4	2.0	4.8	.3
14	18.0	7.9	13.1	8.8	5.4	1.9	11.5	2.1	4.3	.3
15	17.9	7.9	15.4	6.0	4.4	2.3	7.6	3.3	3.2	.7
16	16.9	7.3	17.9	4.8	3.8	3.0	4.0	5.3	2.4	.6
17	15.5	7.4	20.2	4.8	3.4	2.6	3.2	6.1	2.2	.5
18	13.4	7.5	22.0	6.1	3.1	3.8	2.7	7.0	1.8	.4
19	10.1	7.7	23.4	7.4	3.3	5.7	2.4	7.5	1.8	.4
20	7.4	8.1	22.9	8.5	3.2	4.8	2.9	8.2	1.5	.3
21	6.1	8.5	21.6	9.8	3.5	2.9	2.5	9.5	1.4	.3
22	5.4	8.3	19.6	10.4	3.7	2.2	2.2	11.0	1.2	.3
23	5.0	8.0	17.2	9.7	4.7	1.9	2.0	12.0	1.0	.1
24	4.9	7.7	15.5	7.4	4.7	1.9	1.8	11.7	.9	.1
25	4.7	7.4	14.0	5.5	4.8	1.8	1.7	9.7	.8	.1
26	7.8	6.8	12.6	5.0	5.6	1.7	1.5	5.5	.6	.0
27	10.5	6.1	10.9	5.0	6.7	1.6	1.4	3.3	.5	.0
28	10.7	5.7	9.0	6.6	7.8	1.6	1.3	3.3	.4	.0
29	11.8	.....	7.5	7.8	8.4	2.5	1.2	3.9	.3	.0
30	13.2	.....	6.8	8.8	9.2	2.0	1.2	3.0	.3	.1
31	14.0	.....	5.6	.....	9.0	.....	1.0	2.4	.....	.1

Oconee River[1] *at Dublin, Georgia, for 1896.*

[No record was kept at this station from May to October, 1896. Capt. J. D. Roberts, in charge of the steamers Henry and Gipsy, states that from the 15th of September to the 15th of October, 1896, occurred the lowest water in six years, the gage at Dublin going down to —1.20 and remaining at about that level for nearly thirty days. This information is valuable and authentic.]

Day.	Jan.	Feb.	Mar.	Apr.	Oct.	Nov.	Dec.
1	4.1	6.0	6.6	3.0	.....	0.5	3.2
2	5.0	4.5	6.8	3.8	.....	.1	6.7
3	4.7	4.4	6.4	5.5	.....	.4	9.5
4	3.6	6.5	5.4	5.8	.....	1.1	10.7
5	2.8	6.4	5.0	5.0	.....	5.4	11.4
6	2.2	8.4	4.0	4.4	.....	7.7	12.8
7	1.9	11.0	3.8	3.5	.....	19.3	13.1
8	1.9	11.6	4.6	3.0	.....	10.5	12.4
9	2.7	14.8	6.4	2.8	.....	0.2	10.1
10	4.0	17.0	6.2	2.7	.....	7.5	7.3
11	4.0	16.8	5.8	2.6	.....	3.4	6.5
12	3.5	16.5	6.7	2.4	.....	2.5	5.6
13	3.0	15.9	7.3	2.3	.....	2.5	4.5
14	2.5	15.0	7.6	2.2	.....	3.6	4.1
15	2.3	13.4	7.0	2.1	.....	3.7	4.1
16	2.0	11.2	5.8	2.0	.....	3.9	4.0
17	3.5	9.6	5.2	1.9	1.1	3.5	8.0
18	6.7	8.7	4.8	1.8	1.1	2.5	8.9
19	7.5	6.7	4.6	1.7	1.1	1.7	9.7
20	8.0	5.8	4.4	1.7	1.2	1.5	8.1
21	8.0	5.2	4.7	1.6	1.2	1.3	5.3
22	6.4	4.8	4.6	1.4	1.2	1.1	4.1
23	5.0	4.6	4.3	1.2	1.2	1.0	3.7
24	6.9	4.2	4.1	1.0	1.2	.9	3.2
25	8.3	4.1	3.9	.9	1.1	.8	3.0
26	8.9	4.0	4.5	.9	.6	.6	2.8
27	10.0	4.0	4.4	1.1	.2	.5	2.5
28	11.4	3.9	4.2	1.1	.1	.6	2.3
29	12.3	5.0	3.9	1.5	.2	.6	2.3
30	12.0	.....	3.7	1.8	.4	.6	2.2
31	10.9	.....	3.3	.....	.6	.....	2.2

[1] Record from United States Weather Bureau.

Oconee River at Cary, Georgia.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1	2.10	5.10	9	1.80	2.90	17	.....	2.40	25	1.90	2.00
2	1.90	4.80	10	1.80	2.70	18	.....	2.20	26	1.90	2.10
3	1.70	4.40	11	1.80	2.60	19	.....	2.40	27	1.80	2.00
4	2.10	4.20	12	1.90	2.50	20	.....	2.30	28	1.90	1.90
5	2.70	3.70	13	1.80	2.40	21	.....	2.20	29	2.90	2.10
6	2.30	3.40	14	1.90	2.30	22	.....	2.20	30	3.90	2.00
7	2.20	3.20	15	1.90	4.00	23	.....	2.10	31	.....	2.00
8	1.80	3.00	16	2.00	2.80	24	.....	2.00			

Ocmulgee River[1] *at Macon, Georgia, for 1893.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	5.30	12.70	2.40	1.60	2.60	1.00	1.40	9.30	1.30	1.70	2.50
2	.....	4.80	10.00	2.30	1.40	2.40	1.10	1.80	8.70	1.30	1.60	3.00
3	.....	3.90	7.80	2.20	1.80	5.40	1.10	2.20	5.50	1.50	1.60	2.80
4	.....	3.10	12.70	2.10	6.70	6.80	1.80	1.80	3.00	8.00	1.60	2.70
5	.....	2.80	12.20	2.10	3.40	6.70	1.00	2.00	2.80	5.00	1.60	2.50
6	.....	3.40	9.50	2.30	3.10	5.10	1.00	6.20	2.40	3.50	1.60	3.20
7	.....	2.30	7.10	2.50	7.20	5.50	1.00	13.40	2.40	3.00	1.50	2.00
8	.....	1.80	6.50	2.20	4.90	9.70	1.00	9.50	2.30	2.80	1.50	1.80
9	.....	1.60	4.70	2.00	4.90	7.00	1.80	5.00	3.00	2.70	1.50	1.70
10	.....	1.30	8.90	1.80	3.40	3.40	1.20	3.20	4.00	2.60	1.50	1.60
11	.....	2.80	7.80	1.70	2.90	2.50	1.20	2.00	4.10	2.60	1.50	1.50
12	.....	4.60	5.80	1.70	2.20	2.20	1.20	1.80	5.40	2.50	1.50	1.50
13	.....	14.60	5.00	1.60	1.80	2.00	1.10	1.70	9.40	2.50	1.50	1.50
14	.....	13.00	4.10	1.60	1.60	3.00	1.10	1.70	10.90	2.80	1.50	1.50
15	.....	11.20	3.50	1.60	1.30	3.00	1.10	4.20	6.80	2.70	1.50	1.50
16	.....	11.00	2.60	1.70	1.20	3.00	.90	4.00	4.00	2.50	1.50	1.50
17	.....	13.40	3.00	1.60	1.50	2.00	.90	2.00	3.50	2.50	1.50	3.00
18	.....	12.00	2.40	1.40	1.20	1.80	1.00	1.90	2.00	2.50	1.50	2.80
19	.....	11.30	2.20	1.20	1.20	3.00	1.40	1.70	2.00	2.40	1.50	3.50
20	.....	10.60	2.10	2.50	1.00	2.60	1.60	1.60	1.60	2.20	1.50	3.20
21	2.70	6.80	.....	9.00	.80	2.30	1.70	1.60	1.60	2.10	2.00	3.10
22	2.80	4.80	.....	7.40	.70	2.40	5.40	1.40	1.50	2.10	2.80	3.00
23	2.80	3.30	.....	4.30	.60	2.20	2.40	1.30	1.50	2.00	3.00	2.80
24	2.60	5.40	2.90	2.90	.70	2.20	2.20	1.30	1.50	2.00	2.80	2.60
25	4.60	4.00	3.70	2.20	.60	2.20	2.00	1.20	1.40	2.00	2.60	2.40
26	5.00	3.60	5.30	1.80	.60	1.00	1.80	1.20	1.40	2.00	2.40	3.20
27	4.70	3.50	4.00	1.80	.70	1.00	1.80	1.10	1.60	2.00	2.30	2.00
28	5.30	11.90	3.10	1.70	.40	1.00	2.00	1.20	1.50	1.80	2.10	1.90
29	5.80	.....	2.80	1.60	.20	1.10	1.40	1.40	1.40	1.70	2.00	1.80
30	6.30	.....	2.60	1.60	6.10	1.00	1.30	1.40	1.40	1.70	2.00	2.50
31	6.60	.....	2.50	.....	5.60	.....	1.20	2.00	.....	1.70	.....	3.40

[1] Record from United States Weather Bureau.

Ocmulgee River[1] *at Macon, Georgia, for 1894.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.20	2.30	10.40	3.00	1.80	1.20	1.80	7.00	3.40	.90	5.00	1.00
2	3.00	2.00	9.10	3.00	1.70	1.20	1.60	6.00	3.20	.90	5.60	1.00
3	2.80	2.00	8.60	2.50	1.50	1.20	1.40	5.80	3.00	.90	7.00	.90
4	2.60	3.00	8.00	2.50	1.50	1.20	1.30	4.80	2.80	.80	6.50	1.00
5	2.30	2.80	4.90	3.00	1.50	1.20	1.20	9.00	2.60	.80	6.00	1.50
6	2.00	2.60	4.20	2.80	1.50	1.10	2.50	14.20	3.00	.80	5.00	1.50
7	1.80	2.40	3.90	2.80	1.50	1.10	3.00	12.20	4.00	.80	4.00	1.40
8	1.60	2.30	3.80	2.50	1.50	1.00	2.80	9.60	6.00	.90	3.00	1.30
9	3.70	2.20	3.70	2.50	1.50	1.00	2.60	6.90	5.50	11.00	2.80	1.30
10	3.30	2.10	3.50	2.50	1.30	1.00	3.00	5.40	5.00	15.10	2.40	2.00
11	4.50	3.00	3.20	5.60	1.30	.90	4.00	4.00	4.80	8.00	2.30	4.00
12	6.00	7.20	7.10	5.20	1.30	.90	3.80	4.00	4.60	6.00	2.10	9.80
13	6.80	10.00	7.90	5.00	1.20	.90	3.40	3.80	5.00	4.50	2.00	13.20
14	5.50	11.00	6.00	4.60	1.50	1.00	3.20	3.60	5.80	4.30	2.00	10.30
15	3.20	13.70	4.00	4.00	3.00	.90	3.00	3.40	4.60	4.10	1.90	8.40
16	3.80	9.80	3.50	3.80	2.50	.90	2.80	3.10	4.30	3.90	1.80	7.20
17	4.20	7.50	4.00	3.50	2.00	.90	3.00	3.00	4.20	3.60	1.70	3.00
18	3.30	6.20	6.00	3.00	1.70	1.00	3.00	3.00	5.00	3.40	1.70	2.50
19	3.00	5.70	5.00	2.80	2.50	.90	7.60	4.00	5.30	3.20	1.50	2.40
20	2.80	5.20	4.60	6.50	2.30	.90	6.80	3.00	11.30	3.10	1.50	2.20
21	3.00	4.90	4.30	6.00	2.00	.80	7.90	4.50	5.50	3.00	1.50	2.10
22	3.20	5.10	4.00	5.80	1.70	2.00	4.00	4.00	3.00	2.80	1.50	2.00
23	3.00	5.20	3.80	5.50	1.50	2.50	3.00	3.80	2.80	2.60	1.50	2.00
24	3.60	5.60	3.50	4.00	1.30	2.00	3.00	3.60	2.60	2.40	1.40	1.90
25	3.20	6.00	3.20	3.70	1.30	3.00	2.60	5.00	2.70	2.30	1.30	1.80
26	3.30	8.90	6.00	3.50	1.30	2.50	2.30	4.80	2.30	2.10	1.30	1.70
27	3.20	10.40	5.60	3.20	1.30	2.00	3.00	4.60	2.20	2.00	1.20	3.00
28	3.00	9.50	4.00	2.30	1.30	1.80	4.00	4.20	2.10	1.80	1.20	4.00
29	2.80	.....	3.50	2.00	1.30	1.60	3.70	4.00	1.00	1.70	1.10	3.90
30	2.70	.....	3.20	2.00	1.30	2.00	4.00	3.80	1.00	1.60	1.00	3.70
31	2.50	.....	3.00	.....	1.20	.....	7.20	3.60	.....	4.00	.....	3.50

Ocmulgee River[1] *at Macon, Georgia, for 1895.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.50	6.00	3.00	4.60	6.00	3.80	10.90	2.80	4.40	*a*2.00	0.50	0.50
2	3.40	6.00	4.00	4.50	5.50	3.70	10.00	2.80	4.20	1.80	.77	.50
3	3.20	5.80	10.80	4.30	4.00	3.60	7.80	2.80	4.00	1.60	.85	.65
4	3.00	5.30	10.00	4.20	3.80	3.50	11.80	4.00	5.00	1.40	.67	.62
5	3.00	5.10	6.00	4.00	3.70	3.50	10.00	6.00	4.80	1.40	.55	.54
6	2.80	4.00	4.00	4.00	3.60	3.40	9.50	5.80	4.60	1.20	.45	.51
7	2.70	4.00	5.70	3.90	3.60	3.30	9.00	5.60	4.30	1.00	.36	.44
8	2.60	3.90	10.90	11.20	3.60	3.20	13.40	5.40	4.20	1.00	.47	.40
9	3.00	3.70	8.50	11.00	3.60	3.20	10.00	5.30	4.00	1.00	.55	.46
10	15.00	3.60	6.00	8.00	5.00	3.00	7.00	5.00	3.90	.80	.63	.45
11	14.50	3.50	4.00	7.00	5.00	3.00	5.00	4.90	5.00	.60	.65	2.50
12	11.50	3.50	4.00	6.50	5.50	2.90	4.00	4.70	4.80	.70	.60	2.29
13	7.00	4.00	6.00	6.00	5.30	2.90	3.90	4.50	4.50	.65	.77	1.51
14	6.00	4.20	14.50	5.80	5.00	3.00	3.70	4.60	4.20	.40	.94	1.11
15	5.00	4.70	15.80	5.30	4.80	4.00	3.50	7.00	4.10	.30	.72	1.01
16	3.00	4.50	16.40	5.00	4.60	4.00	3.40	9.70	4.00	.20	.65	1.72
17	2.90	4.20	18.40	4.80	4.20	4.50	3.30	12.20	3.90	.20	.57	.58
18	2.70	4.10	16.80	12.50	5.00	4.30	3.20	13.00	3.70	.17	.55	.64
19	2.60	4.00	12.00	10.00	4.20	4.00	3.30	12.00	3.60	.20	.50	.61
20	2.50	3.90	9.00	8.00	4.00	3.90	3.60	9.00	3.50	.18	.50	.59
21	2.20	3.60	11.00	7.00	3.80	3.80	3.50	6.00	3.50	.25	.50	2.02
22	2.10	3.50	9.00	6.00	4.00	3.70	3.40	10.00	3.50	.22	.50	3.10
23	2.00	3.50	8.00	6.50	4.50	4.00	3.30	9.00	3.40	.21	.50	2.68
24	2.00	3.40	7.00	6.00	5.00	3.90	3.30	6.00	3.40	.21	.50	1.70
25	2.00	3.30	6.00	4.80	5.00	3.80	3.20	4.50	3.30	.17	.49	1.48
26	12.50	3.20	5.80	4.70	7.00	3.70	3.10	4.00	3.20	.19	.49	1.01
27	8.00	3.20	5.50	8.10	12.50	3.50	3.00	4.00	3.20	.18	.47	1.00
28	7.00	3.10	5.40	10.90	7.00	3.40	3.00	5.00	3.20	.18	.43	1.20
29	11.00	.....	5.30	10.00	5.00	3.20	2.90	4.00	3.10	.17	.55	1.30
30	11.00	.....	5.00	7.00	4.00	.....	2.90	4.00	3.00	.22	.54	1.35
31	7.00	.....	4.80	.....	3.90	.....	2.90	4.50	.....	.50	.....	4.46

[1] Record from United States Weather Bureau.
a From October 1 to 23, estimated by B. M. Hall.

Ocmulgee River at Macon, Georgia, for 1896.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.81	3.00	a2.50	3.10	0.89	0.08	—0.90	1.02	0.11	—0.82	—0.14	9.50
2	3.50	2.90	2.20	3.00	.75	—.11	—1.00	1.50	.12	—.86	—.08	11.08
3	2.20	3.20	2.10	4.60	.63	.56	+.10	1.82	.11	—.88	—.02	12.60
4	1.70	3.00	2.00	3.40	.90	.85	.15	2.22	.28	—.81	10.00	10.20
5	1.42	2.90	2.00	2.90	2.12	1.92	2.00	2.62	.19	—.75	14.20	8.00
6	1.08	13.50	1.90	1.80	2.73	1.52	4.00	3.00	.19	—.79	14.40	6.15
7	.96	10.70	4.00	1.60	1.97	.96	5.30	3.05	.19	—.78	8.80	4.52
8	1.72	7.50	6.00	1.10	1.62	.73	11.00	2.78	.12	—.82	5.40	3.62
9	2.83	13.10	5.00	1.10	.86	.25	20.00	2.41	.08	—.82	3.22	3.00
10	2.77	11.30	4.00	1.40	.61	.01	19.40	1.88	.04	—.82	2.25	2.42
11	2.10	8.70	5.00	1.30	.38	—.05	15.00	1.48	.01	—.73	1.50	1.98
12	1.60	7.00	7.20	1.10	.30	—.10	10.20	.40	—.01	—.62	1.18	1.58
13	1.50	6.30	6.50	1.20	.19	—.17	8.20	.20	—.31	—.75	10.00	1.26
14	1.20	6.50	6.20	1.20	.11	.29	7.10	.13	—.45	—.73	8.10	1.12
15	2.00	5.00	6.00	1.13	.09	.32	7.00	.25	—.80	—.65	5.32	11.70
16	2.50	4.80	6.00	1.12	.07	.20	6.20	1.08	—.68	—.77	1.53	6.00
17	7.20	4.20	5.50	1.09	.05	.25	16.00	.50	—.78	—.80	1.14	4.62
18	5.00	3.40	5.30	1.05	.03	.25	18.20	.60	—.80	—.83	.97	3.94
19	4.50	3.20	5.00	.98	—.05	.30	13.00	.38	—.82	—.85	.85	2.85
20	4.00	3.00	4.90	.94	—.10	.40	7.05	.20	—.91	—.88	.63	2.38
21	3.90	2.90	4.70	.86	—.10	.47	3.80	.11	—.90	—.89	.70	2.00
22	3.70	2.70	4.50	.76	—.15	.56	3.20	.08	—.82	—.90	.62	1.90
23	9.40	2.60	4.20	.71	—.05	.70	3.00	—.06	—.41	—.73	.58	1.76
24	13.80	2.50	5.00	.63	.56	.50	2.90	—.05	—.48	—.40	.58	1.38
25	12.00	2.48	5.00	.63	.50	.30	2.85	.00	—.61	—.52	.51	1.18
26	9.30	2.40	4.80	1.02	.78	—.20	2.70	—.03	—.72	—.25	.51	1.11
27	7.00	2.30	4.70	2.90	.52	—.35	2.40	—.04	—.78	—.08	.50	.96
28	5.80	3.30	4.60	2.32	.34	—.65	2.10	—.07	—.83	—.20	.47	.90
29	5.30	2.80	4.40	1.36	.17	—.75	1.92	—.07	—.91	—.32	.44	.83
30	4.80	.....	4.20	1.02	.12	—.85	1.66	—.09	—.80	—.23	.32	.78
31	3.20	.....	4.10	.....	.12	.....	1.41	—.12	.....	—.18	.....	.70

a Gage heights from March 1 to April 14 supplied from Weather Bureau records.

Chattahoochee River at Oakdale, Georgia, for 1895.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1	.....	0.75	0.50	12	.....	1.35	1.10	23	0.20	0.50	2.00
2	.....	1.70	.50	13	.....	1.00	1.00	24	.30	.50	1.20
3	.....	1.00	.55	14	.....	.75	.65	25	.25	.50	1.00
4	.....	.60	.60	15	0.40	.60	.60	26	.20	.55	.55
5	.....	.50	.60	16	.40	.60	.55	27	.25	.55	.80
6	.....	.55	.50	17	.35	.55	.55	28	.25	.70	.75
7	.....	.45	.45	18	.30	.60	.50	29	.30	.75	.70
8	.....	.40	.40	19	.25	.50	.40	30	.50	.45	2.00
9	.....	.60	.40	20	.30	.55	.50	31	.50	.....	2.95
10	.....	.80	.60	21	.20	.50	.65				
11	.....	1.00	1.30	22	.25	.50	1.00				

Chattahoochee River at Oakdale, Georgia, for 1896.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.20	1.70	1.40	1.40	0.75	0.25	0.35	0.45	—0.40	0.20	0.50	0.65
2	2.00	1.55	1.35	1.70	.75	1.40	.40	.50	— .60	.10	.50	1.20
3	1.00	1.75	1.40	2.75	.75	1.45	— .45	1.40	— .60	.05	.65	1.70
4	1.20	2.10	1.45	1.85	.70	2.10	+ .15	1.70	— .60	— .20	1.13	3.20
5	1.10	2.20	1.40	1.35	.65	1.60	.20	.75	— .60	— .30	1.60	2.30
6	1.00	2.80	1.35	1.30	3.15	1.15	— .15	.40	— .60	— .35	1.35	1.30
7	.80	3.70	1.95	1.10	1.70	.60	+2.00	.20	— .60	— .40	1.20	1.15
8	.95	4.30	1.75	1.15	1.20	.40	12.25	.15	— .55	— .50	1.10	1.00
9	1.20	5.80	1.55	1.05	.90	.70	17.70	.15	— .55	— .50	1.00	1.00
10	1.25	6.55	1.50	1.05	.75	.70	18.45	.10	— .50	— .50	1.05	1.00
11	1.00	4.30	1.75	1.05	.65	.65	4.75	.05	— .50	— .60	1.05	.90
12	.85	3.30	1.85	1.00	.60	.50	3.25	.05	— .55	— .60	1.60	.70
13	.80	2.80	1.55	1.00	.50	.30	3.10	.30	— .60	— .55	3.80	.60
14	.75	2.95	1.35	.90	.50	.20	2.90	.25	— .60	— .55	4.60	.65
15	.70	4.10	1.20	.90	.40	— .05	1.95	.05	— .60	— .55	2.60	.70
16	.85	2.90	1.15	.90	.30	+ .05	3.00	.10	— .65	— .55	1.50	.65
17	2.40	2.55	1.10	.85	.30	— .05	4.40	.10	— .65	— .55	1.00	.65
18	2.35	2.20	1.35	.85	.25	+ .10	2.70	.10	— .65	— .55	.80	.65
19	2.10	2.10	1.70	.85	.25	.15	1.75	— .10	— .65	— .55	.60	.65
20	1.50	1.80	1.65	.85	.20	.55	1.90	— .25	— .65	— .55	.50	.65
21	1.25	1.60	1.45	.75	.15	1.60	1.65	— .30	— .50	— .55	.40	.60
22	1.80	1.45	1.35	.75	.20	.45	1.90	— .30	— .15	— .50	.40	.55
23	6.30	1.55	1.40	.65	.20	.50	2.45	— .30	+ .40	— .23	.30	.50
24	9.80	1.60	1.45	.70	1.10	.30	2.40	— .30	.60	— .05	.25	.50
25	9.95	1.50	1.40	.65	1.55	.20	1.50	+1.00	— .10	+ .05	.20	.45
26	5.10	1.40	1.35	.65	.65	— .10	1.30	— .10	— .40	.10	.20	.45
27	3.55	1.35	1.25	1.40	.85	+ .45	.90	— .30	— .40	.15	.20	.40
28	2.65	1.30	1.20	1.70	.65	— .10	.80	— .20	+ .20	.25	.20	.35
29	2.30	1.55	1.15	1.15	.95	— .20	.80	— .30	.45	.90	.20	.35
30	2.10	.....	1.20	.85	.40	— .25	.80	— .35	.30	.65	.20	.30
31	1.80	.....	1.20	.....	.35	.....	.50	— .40	.....	.50	.....	.25

Chattahoochee River at Westpoint, Georgia, for 1896.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.70	1.30	4.10	1.70	4.20	17	1.60	0.85	1.10	3.00	3.00
2	3.90	1.20	4.00	2.00	4.00	18	1.55	.80	1.10	2.60	3.00
3	4.50	1.10	3.00	3.25	3.75	19	1.50	.80	1.10	2.55	2.90
4	6.00	1.05	2.60	8.00	3.60	20	1.45	.80	1.10	2.40	2.80
5	5.50	1.00	2.40	9.20	3.40	21	1.40	.80	1.15	2.25	2.70
6	5.00	1.00	2.00	7.60	3.20	22	1.40	3.30	1.10	2.25	2.60
7	3.65	1.00	1.90	5.50	3.10	23	1.30	3.00	1.50	2.20	2.40
8	3.20	1.05	1.50	4.30	3.10	24	1.20	2.50	1.75	2.20	2.20
9	2.75	1.10	1.30	3.45	3.05	25	3.00	2.00	1.75	2.90	2.15
10	2.60	1.05	1.25	2.80	3.00	26	2.00	1.70	1.70	1.90	2.10
11	2.20	.95	1.25	2.00	2.90	27	1.80	1.60	1.65	1.80	2.10
12	2.00	.85	1.20	2.15	2.80	28	1.75	1.40	1.60	2.00	2.05
13	1.85	.85	1.15	6.30	2.65	29	1.60	3.60	1.50	4.00	2.00
14	1.70	.90	1.15	5.00	2.50	30	1.50	4.20	1.50	4.30	1.95
15	1.60	.90	1.15	4.50	3.00	31	1.40	.....	1.45	.....	1.90
16	1.60	.85	1.15	3.30	3.10						

Etowah River[1] *at Canton, Georgia, for 1892.*

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.00	1.00	0.80	1.00	0.80	0.80	0.10	0.10	0.20
2	.....	1.00	1.00	.80	.80	.30	.60	.00	.10	.20
3	.....	1.00	1.00	2.00	.70	.30	.40	.00	.10	.20
4	.....	1.00	1.00	3.80	.70	.30	.30	.00	.10	.20
5	.....	1.00	1.00	1.00	2.00	.30	.20	.00	.10	.20
6	.....	9.00	1.00	1.50	2.00	.30	.10	.00	.10	.10
7	.....	17.80	1.00	.80	1.50	.30	.10	.00	.10	.10
8	.....	11.80	1.00	.80	1.00	.20	.10	.00	.20	.10
9	.....	4.00	1.00	.60	.80	.20	.10	.00	1.00	.10
10	.....	3.00	1.00	.60	2.40	.20	.10	.00	3.00	.10
11	.....	2.00	1.50	.60	5.20	.20	.10	.00	1.00	.10
12	1.10	2.00	1.10	.60	5.60	.20	.10	.00	.50	.10
13	1.00	2.20	1.00	.60	3.00	.20	.20	.00	.40	.10
14	.90	2.20	.90	.50	1.80	.20	1.00	.00	.30	.10
15	.90	2.20	.80	.40	1.80	.20	.80	.00	2.00	.10
16	.90	2.20	.80	.40	1.00	.10	.60	.00	1.00	.10
17	.80	2.10	.90	.40	.80	.20	.50	.00	.50	1.00
18	1.40	1.80	1.20	.40	.60	.80	.40	.00	2.00	.60
19	.90	1.70	1.80	.60	.50	.60	.30	.00	1.00	.40
20	.90	5.40	1.00	1.80	.60	.60	.20	.00	.80	2.00
21	.90	2.30	.90	1.40	.50	.60	.20	.00	.60	1.50
22	.80	1.90	.90	1.00	.70	.70	.20	.00	.40	1.00
23	.80	2.20	1.00	1.00	.70	.90	.20	.00	.40	.50
24	1.20	2.00	.90	.80	.60	1.50	.20	.00	.30	.40
25	1.40	2.00	.90	.70	.60	1.50	.10	.00	.20	.40
26	6.00	1.50	.80	1.70	.60	1.00	.10	.00	.20	.40
27	5.00	1.40	.80	1.00	.50	1.00	.10	.10	.20	.40
28	2.40	1.10	.80	2.00	.40	.80	.10	.10	.30	.40
29	1.80	1.00	.80	1.00	.40	.80	.10	.10	.20	.40
30	1.40	1.00	.80	1.00	.30	.60	.10	.10	.20	.40
31	1.40	.....	.80	.....	.30	.60	.....	.10	.....	.40

Etowah River[1] *at Canton, Georgia, for 1893.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.30	0.60	2.00	0.80	0.30	0.60	0.60	0.10	1.00	0.00	—0.20	0.10
2	1.00	.50	1.00	.70	.30	2.00	1.00	.50	.80	.00	—.20	.10
3	.60	.40	1.00	.70	.90	5.60	.60	.30	.60	.00	—.20	.10
4	.50	.40	1.00	.70	1.20	2.00	.50	.20	.40	.00	—.20	.40
5	.40	.40	1.00	.70	.90	1.00	.50	.80	.20	—.10	—.20	.40
6	.30	.30	1.00	.70	.90	3.00	.40	.60	.00	—.10	—.20	.20
7	.30	.30	1.00	.70	2.00	3.80	.40	.40	.00	—.10	—.20	.20
8	.30	.30	1.00	.60	1.00	2.00	.40	.30	.00	—.10	—.20	.20
9	.30	.30	4.80	.60	2.00	1.00	.40	.30	.10	—.10	—.20	.20
10	.30	.20	2.00	.60	1.00	.60	.40	.30	1.00	—.20	—.20	.20
11	.30	2.00	1.20	.50	.90	.60	.40	.30	3.00	—.20	—.20	.20
12	.30	2.20	1.50	.50	.80	.60	.30	.30	4.00	—.20	—.20	.20
13	.40	4.20	1.30	.50	.70	.60	.30	.30	3.80	—.20	—.20	.10
14	.40	3.00	1.00	.50	.70	.50	.30	.30	1.50	—.20	—.20	.00
15	.40	3.00	1.00	.40	.60	.50	.30	.30	1.00	—.20	—.20	.00
16	.30	12.00	1.00	.40	1.00	.50	.30	.30	.50	—.20	—.20	.20
17	.30	5.00	.80	.40	.90	.50	.30	.30	.30	—.20	—.20	.20
18	.30	3.00	.80	.40	.80	.40	.30	.20	.10	—.20	—.20	.20
19	.50	2.00	.70	.40	.80	.40	.30	.10	.10	—.20	—.20	.20
20	.50	1.50	.70	.40	.70	3.00	.30	.10	.10	—.20	—.20	.20
21	.40	1.40	.60	.40	.60	1.00	.30	.10	.00	—.20	—.20	.10
22	.40	1.30	.50	.40	.50	.80	1.00	.10	.00	—.20	—.20	.10
23	.40	1.00	.40	.30	.50	2.60	.80	.00	.00	—.20	.00	.10
24	.40	1.00	.80	.30	.40	1.00	.60	.00	.00	—.20	.00	.10
25	.40	1.00	1.40	.30	.40	.80	.50	.00	.00	—.20	.00	.10
26	.40	.80	1.00	.30	.40	.80	.40	—.10	.00	—.20	.00	.10
27	.40	.80	1.00	.30	.40	.70	.30	—.10	.00	—.20	.00	.10
28	.60	3.00	.80	.30	.40	.60	.20	—.10	—.10	—.20	.00	.10
29	1.50	.....	.80	.30	.90	.60	.10	—.10	—.10	—.20	+ .20	.10
30	1.40	.....	.80	.30	1.60	.50	.10	—.10	—.10	—.20	.20	.20
31	1.00	.....	.80	.....	1.00	.....	.10	.....	.....	—.20	.....	.20

[1] From United States Weather Bureau records.

Etowah River[1] *at Canton, Georgia, for 1894.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.20	0.50	0.80	0.70	0.60	0.50	0.60	0.60	0.50	0.60	0.50	0.50
2	.20	.50	.80	.70	.60	.50	.60	.50	.50	.60	.50	.50
3	.20	.50	.80	.70	.60	.50	.60	.50	.50	.60	.50	.50
4	.20	.50	.80	.70	.60	.50	.60	1.50	.50	.60	.50	.50
5	.20	.50	.80	.80	.60	.50	.60	.50	.50	.60	.50	.50
6	.20	.50	.80	.80	.60	.50	.60	.50	.50	.60	.50	.50
7	2.00	.50	80	.80	.60	.50	.60	.50	.50	.60	.50	.50
8	1.00	.50	.80	.80	.60	.40	.60	.50	.50	.60	.50	.50
9	1.00	1.50	.70	.80	.60	.40	.60	.50	.50	.60	.50	.50
10	1.80	1.00	.60	.80	.60	.30	.60	.50	.50	.60	.50	1.00
11	2.00	.80	.50	1.80	.60	.20	.60	.50	.50	.60	.50	2.00
12	1.00	1.00	.50	.80	.60	.20	.60	.50	.50	.60	.40	7.50
13	1.00	1.00	.40	.80	.60	.20	.60	.50	.50	.60	.40	2.00
14	.80	1.00	.40	.80	.60	.20	.50	.50	.50	.60	.40	1.00
15	1.80	1.00	.40	.70	.80	.20	.50	.50	.50	.60	.50	.60
16	1.00	1.00	.40	.60	.80	.20	.50	.50	.50	.60	.50	.60
17	.80	1.00	.40	.50	.80	.20	.50	.40	.50	.60	.50	.60
18	.60	1.00	.40	.50	.80	.90	1.00	.40	5.20	.60	.50	.60
19	.60	1.50	.40	.50	.80	.80	1.00	.40	1.20	.60	.50	.60
20	.80	1.50	.40	.80	.60	.60	1.00	.40	1.00	.60	.50	.60
21	.80	1.00	2.00	.80	.60	.60	.50	.40	.60	.60	.50	.60
22	.80	.80	1.80	.80	.60	.60	3.00	.40	.60	.60	.50	.60
23	.80	.80	.80	.60	.60	.60	1.00	.40	.60	.60	.50	.60
24	.80	.80	.80	.60	.60	.60	.50	.40	.60	.60	.50	.60
25	.80	.80	.80	.60	.60	.60	.50	1.00	.60	.50	.50	.60
26	.60	.80	.80	.60	.60	.60	.50	2.40	.50	.50	.50	.60
27	.50	.80	.80	.60	.60	.60	.50	1.00	.50	.50	.50	1.80
28	.50	.80	.80	.60	.60	.60	.50	.50	.60	.50	.50	1.80
29	.50	.....	.80	.60	.50	.60	.50	.50	.60	.50	.50	.80
30	.50	.....	.80	.60	.50	.60	.50	.50	.60	.50	.50	.80
31	.50	.....	.80	.....	.50	.....	.....	.50	.....	.50	.....	.80

Etowah River[1] *at Canton, Georgia, for 1895.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.80	1.00	1.00	1.00	1.40	1.00	2.00	0.60	0.80	0.40	0.10	0.30
2	.80	1.00	1.00	1.00	1.60	1.00	1.00	.60	.80	.40	.10	.30
3	.80	1.00	2.00	1.00	1.00	.80	1.00	.60	.80	.40	.10	.30
4	.80	1.00	2.00	1.00	1.00	.80	1.00	.60	.80	.40	.10	.30
5	.80	1.00	2.00	1.00	1.00	.80	1.00	.50	.80	.40	.10	.30
6	.80	1.00	1.00	1.00	1.00	2.00	.80	.50	.80	.30	.00	.30
7	.80	1.00	1.00	1.50	1.00	1.00	1.00	.50	.80	.30	.00	.30
8	.80	1.00	1.00	4.50	1.00	1.00	2.50	2.00	.80	.30	.00	.30
9	7.60	1.00	1.00	2.00	1.00	1.00	2.00	.80	.80	.30	.00	.40
10	15.50	1.00	1.00	1.60	1.00	1.00	1.00	.80	.80	.30	.00	.50
11	9.80	1.00	1.00	1.40	1.00	.80	1.00	.80	.80	.30	.00	.50
12	3.00	1.00	1.00	1.40	1.00	1.00	.80	.80	.80	.30	.60	.50
13	1.50	1.00	2.00	1.20	.80	1.00	.80	.80	.80	.30	.60	.50
14	1.00	1.00	3.50	1.20	.80	1.00	.80	2.00	.80	.30	.50	.50
15	1.00	1.00	4.00	1.20	.80	.80	.80	1.00	.80	.30	.50	.50
16	1.20	1.00	6.00	1.20	.80	.80	.80	3.60	.80	.30	.50	.50
17	1.80	1.00	3.00	6.00	.80	1.00	.70	10.50	.80	.30	.50	.50
18	1.00	1.00	2.00	3.00	.80	.80	.90	2.50	.80	.30	.50	.50
19	1.00	1.00	1.60	1.50	.80	.80	.60	1.50	.80	.20	.50	.50
20	1.00	1.00	2.40	1.50	.70	.80	.60	1.00	.80	.20	.40	.50
21	2.00	1.00	5.60	1.40	.70	.80	.60	1.00	.70	.20	.40	1.00
22	2.00	1.00	2.80	1.40	.70	.80	.60	1.00	.70	.20	.40	1.00
23	1.00	1.00	2.00	1.40	1.00	.80	.60	1.00	.60	.20	.40	.60
24	1.00	1.00	2.00	1.30	1.00	.80	.60	1.00	.60	.20	.40	.60
25	1.00	1.00	2.00	1.20	2.80	.80	1.00	1.00	.60	.10	.40	.60
26	2.00	1.00	1.80	1.20	2.80	.80	.80	.80	.80	.10	.40	.60
27	1.00	1.00	1.40	1.60	3.00	.70	.80	.80	.60	.10	.40	.60
28	1.00	1.00	1.00	1.00	2.00	.70	.60	.80	.60	.10	.40	.60
29	2.00	.....	1.00	1.40	2.00	.70	.60	.80	.60	.10	.40	.60
30	1.00	.....	1.00	1.40	1.60	2.00	.60	.80	.50	.10	.40	.60
31	1.00	.....	1.00	.....	1.00	.....	.60	.80	.....	.10	.....	.60

[1] From United States Weather Bureau records.

Etowah River at Canton, Georgia, for 1896.

Day.	Jan.	Feb.	Mar.	Sept.	Oct.	Nov.	Dec.
1	0.60	1.80	0.60	.....	0.00	0.00	1.00
2	.60	1.80	.50	.....	—.20	—.10	1.00
3	.60	1.80	.50	.....	—.30	—.10	.60
4	.60	1.80	.50	.....	—.30	.00	.30
5	.60	1.80	.50	.....	—.40	+2.80	.30
6	.60	2.00	.50	.....	—.40	.80	.20
7	.50	3.00	.80	.....	—.50	.60	.10
8	.70	3.00	.80	.....	—.50	.60	.10
9	.70	3.50	.80	—0.65	—.50	.40	.10
10	.70	2.00	.80	—.60	—.30	.40	.10
11	.70	1.80	.80	—.60	—.30	.40	.10
12	.70	1.80	.80	—.65	—.40	.90	.00
13	.70	1.80	.80	—.70	—.20	3.60	.00
14	.70	1.00	.80	—.75	—.30	1.00	.00
15	.70	1.00	.70	—.60	—.40	.70	.20
16	.70	1.00	.80	—.55	—.40	.70	.40
17	1.00	1.00	.80	—.65	—.40	.40	.20
18	.80	1.00	.70	—.75	—.40	.20	.00
19	.80	1.00	1.00	—.75	—.40	.00	.00
20	.80	1.00	1.00	—.75	—.50	.00	.00
21	.80	1.00	1.00	—.75	—.50	.00	.00
22	1.00	.80	.80	—.60	—.50	.00	.00
23	3.80	.80	.80	—.10	—.50	.00	.00
24	5.80	.80	.80	—.30	.00	.00	.00
25	3.00	.80	.60	—.40	—.10	.00	.00
26	2.00	.60	.60	—.60	—.10	.00	.00
27	2.00	.60	.60	—.60	—.10	.00	.00
28	2.00	.60	.60	—.60	+1.12	.00	—.10
29	1.80	.60	.60	—.60	1.10	.00	—.10
30	1.80	.....	.60	—.70	1.00	1.00	—.10
31	1.80	.....	a 1.00	.....	.00	1.40	—.10

a Weather Bureau discontinued observations March 31, 1896; Geological Survey began observations September 9, 1896.

Coosawattee River at Carters, Georgia.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	0.75	1.25	0.80	2.50	17	0.95	0.50	0.65	0.95	2.35
2	.....	.75	1.10	.85	2.25	18	.90	.50	.60	.90	2.20
3	.....	.75	1.00	1.00	2.00	19	.85	.45	.60	.90	2.05
4	.....	.70	.95	1.05	2.00	20	.80	.50	.55	.90	2.00
5	.....	.70	.95	3.10	1.90	21	.80	.50	.55	.85	1.85
6	.....	.65	.90	1.25	1.80	22	.80	.55	.60	.85	1.85
7	.....	.65	.80	1.00	1.80	23	.75	.65	.80	.85	1.80
8	.....	.60	.70	1.00	1.75	24	.95	.75	1.30	.90	1.70
9	.....	.60	.60	.90	1.65	25	.95	.65	.95	1.00	1.60
10	.....	.65	.50	.90	1.60	26	.95	.60	.60	1.00	1.50
11	.....	.70	.50	6.05	1.50	27	.90	.60	.60	.95	1.50
12	.....	.65	.80	3.50	1.40	28	.90	.55	.70	1.25	1.45
13	.....	.60	.90	2.60	1.40	29	.85	1.60	1.25	1.25	1.40
14	.....	.55	.80	1.40	1.35	30	.85	1.40	.90	3.50	1.40
15	.....	.55	.75	1.00	2.50	31	.80	.....	.80	.....	1.35
16	.....	.55	.70	.90	2.50						

Oostanaula River at Resaca, Georgia, for 1892.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov	Dec.
1	6.00	5.80	3.80	4.00	3.50	4.60	2 30	1.90	2.10
2	5.60	5.50	3.90	4.00	3.50	3.60	2.20	1.90	2.10
3	5.30	5.30	4.60	3.70	4.00	3.00	2.20	2.20	2.20
4	5.10	5.10	10.70	3.60	3.70	3.00	2.20	3.60	2.20
5	5.00	5.00	7.50	4.20	3.30	2.90	2.20	4.00	2.20
6	17.20	4.80	6.60	9.80	3.00	3.00	2.20	3.00	2.20
7	28.70	4.70	5.70	8.70	3.10	3.00	1.90	2 40	2.20
8	32.00	4.70	5.00	7.30	3.00	2.80	1.90	3.60	2.20
9	30.70	4.60	5.60	5.40	3.00	2.70	2.30	4.60	2.20
10	28.10	4.60	6.70	9.20	3.40	2.70	2.10	11.40	2 20
11	24.40	5.50	5.60	13.70	3.70	2.60	2.10	10 00	2.20
12	18.30	5.60	5.00	13.50	3.20	2.50	2.10	6.90	2.20
13	10.20	4.80	4.30	12.50	3.50	2.50	2.10	4.30	2.20
14	8.10	4.50	4.10	10.10	3.20	3.10	2.10	3.70	1.90
15	8.70	4.40	3.80	8.50	3.00	2.90	2.10	6.60	2.20
16	7.70	4.20	3.70	7.50	2.90	2.70	2.00	7 80	2.60
17	7.00	4.20	3.60	6.30	2.80	2.50	2.10	6.20	3.00
18	6.90	4.20	3.60	6.00	3.10	2.50	2.00	5.90	5.60
19	6.70	6.50	3.60	5.20	3.30	2.50	2.00	7.20	6.00
20	8.40	6.00	4.30	6.80	3.20	2.60	1.90	5.70	7.00
21	8.00	5.10	5.20	5.70	3.30	2.90	1.90	4.50	10.00
22	6.90	5.10	6.50	5.50	3 10	5.00	1.90	4.10	8.00
23	7.50	5.30	5.40	5.00	7.10	5.20	1.90	3.90	5.60
24	6.90	4.70	4.50	4.60	9.40	3.20	1.90	3.70	4.00
25	6.30	4.40	4.50	4.30	6.00	2.90	1.90	3.50	3.60
26	6.00	4.20	5.30	4.20	4.60	2.70	1.90	3.30	3.40
27	5.70	4.10	4.60	4.30	4.80	2.60	1.90	3.20	3.00
28	5.60	4.00	7.70	3.80	4.40	2.50	1.90	3.30	2.90
29	5.80	4.00	5.60	3.70	4.00	2.40	1.90	3.90	2.60
30	6.60	3.90	4.40	3.70	3.90	2.30	1.90	3.70	2.50
31	.....	3.90	.....	3.60	4.60	.....	1.90	.....	2.30

Oostanaula River at Resaca, Georgia, for 1893.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.70	4.60	7.80	4.30	3.70	4.40	3.20	2.40	2.30	1.70	1.40	1.90
2	4.80	4.30	6.30	4.20	3.60	7.20	3.20	2.40	3.60	1.70	1.40	1.80
3	4.70	4.00	5.60	4.00	7.00	7.90	3.80	2.50	2.30	1.70	1.50	1.80
4	4.40	4.10	6.60	4.00	14.50	7.20	3.70	2.40	2.00	1.70	1.40	4.00
5	4.00	4.00	7.20	4.20	13.50	5.00	3.30	4.80	1.90	2.00	1.60	3.80
6	3.70	4.00	6.00	4.80	13.40	7.90	3.00	3.20	1.80	1.80	1.60	3.00
7	3.60	4.00	5.50	5.10	8.70	15.10	3.00	3.50	1.70	1.70	1.50	2.40
8	3.50	4.20	5.20	4.40	7.20	12.20	2.90	3.20	1.80	1.70	1.50	2.00
9	3.40	4.00	10.60	4.10	6.20	7.70	3.30	2.90	1.90	1.70	1.50	1.90
10	3.40	3.80	13.30	4.00	5.90	6.00	3.00	2.50	2.10	1.60	1.50	1.90
11	3.00	9.00	9.00	3.90	5.30	5.20	2.90	2.30	2.90	1.60	1.50	1.90
12	3.00	13.00	8.20	3.90	4.80	4.70	2.80	2.20	4.40	1.60	1.50	1.80
13	3.30	14.10	7.80	3.80	4.50	4.40	2.70	2.30	5.60	1.60	1.50	1.80
14	3.00	15.50	6.70	5.00	4.40	4.30	2.60	2.80	5.20	1.60	1.50	1.80
15	3.00	12.20	6.00	7.80	4.20	4.10	2.50	3.20	4.40	1.60	1.50	1.80
16	3.00	18.90	5.40	6.40	4.70	4.00	2.70	2.80	3.20	1.70	1.50	1.90
17	3.00	20.90	5.20	4.60	5.30	3.90	2.50	2.60	2.50	1.60	1.50	2.20
18	3.00	20.10	5.10	4.30	4.80	3.80	2.50	2.30	2.30	1.60	1.50	2.80
19	3.00	18.30	5.00	4.10	4.40	3.80	2.40	2.20	2.10	1.60	1.50	2.50
20	3.00	16.80	4.80	4.40	4.00	3.90	2.60	2.10	2.10	1.60	1.50	2.20
21	3.00	13.60	4.60	5.50	3.80	4.80	2.60	2.00	2.00	1.60	1.60	2.00
22	3.00	7.90	4.50	5.10	3.70	4.50	3.60	1.90	1.90	1.80	2.00	1.90
23	3.00	7.10	4.50	4.30	3.60	6.70	3.20	1.90	1.90	1.70	2.00	1.80
24	3.50	6.40	4.70	4.00	3.60	5.50	2.60	1.90	1.80	1.60	1.80	1.80
25	4.40	5.90	7.70	3.80	3.50	4.20	2.40	1.80	1.80	1.60	1.70	1.70
26	4.80	5.50	6.30	3.90	3.40	3.90	2.30	1.70	1.80	1.60	1.70	1.60
27	4.80	5.20	5.00	4.00	3.30	3.80	2.30	1.70	1.80	1.60	1.70	1.60
28	4.50	6.90	4.70	4.20	3.70	3.70	2.30	1.80	1.80	1.50	1.70	1.60
29	5.20	.....	4.50	4.30	4.90	3.40	2.30	1.80	1.70	1.50	2.20	1.60
30	5.60	.....	4.80	3.80	7.90	3.20	2.20	1.70	1.70	1.50	2.00	2.60
31	5.10	.....	4.50	.....	6.70	.....	2.30	1.60	.....	1.40	.....	3.90

Oostanaula River at Resaca, Georgia, for 1894.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.40	3.20	8.10	3.70	2.90	2.40	1.70	2.10	1.90	1.00	2.10	1.30
2	2.90	3.00	7.60	3.80	2.80	2.30	1.90	2.00	1.80	1.00	1.90	1.30
3	2.50	3.20	6.80	4.60	2.80	2.20	1.80	2.10	1.70	1.00	1.70	1.30
4	3.30	7.90	5.80	4.30	2.90	2.10	1.70	1.80	1.50	1.00	1.60	1.30
5	2.20	9.90	5.20	4.40	2.90	2.00	1.60	2.80	1.40	1.00	1.50	1.30
6	2.30	10.10	4.70	4.30	2.80	2.00	1.50	2.10	1.40	1.00	1.30	1.30
7	2.90	6.50	4.80	3.90	2.70	2.00	1.50	1.80	1.30	1.00	1.20	1.30
8	6.00	4.80	5.20	3.60	2.60	2.00	2.00	1.60	1.30	1.00	1.10	1.30
9	4.60	6.30	4.60	3.50	3.10	1.90	1.70	1.50	1.70	1.10	1.10	1.30
10	5.70	9.30	4.00	3.90	3.10	1.90	1.60	1.50	1.90	1.10	1.10	1.80
11	7.00	7.00	3.90	6.90	3.10	1.90	1.50	1.50	1.60	1.10	1.10	4.10
12	6.50	5.20	5.30	6.40	2.90	1.80	1.50	1.50	1.50	1.10	1.10	11.00
13	5.10	9.60	8.10	5.00	4.40	1.80	1.40	1.50	1.40	1.10	1.00	13.80
14	4.10	8.20	7.60	4.40	5.00	1.80	1.30	1.50	1.40	1.10	1.30	9.20
15	3.60	6.50	5.00	4.10	6.10	1.80	1.30	1.40	1.30	1.00	1.30	4.50
16	5.90	6.20	4.80	3.90	4.50	1.80	1.30	1.60	1.30	1.00	1.30	3.40
17	6.80	5.30	5.90	3.70	3.50	1.70	1.90	1.50	1.20	1.00	1.20	3.00
18	5.30	4.90	5.40	3.60	3.20	1.90	2.70	1.50	2.10	1.00	1.20	3.00
19	4.30	6.30	4.60	3.60	3.10	2.10	2.50	1.80	3.70	.90	1.20	2.70
20	3.80	6.70	4.30	4.20	3.90	2.70	2.70	2.40	2.00	.90	1.20	2.40
21	3.60	6.10	7.20	4.60	3.30	2.20	2.90	2.20	1.80	.90	1.20	2.30
22	4.70	5.50	10.00	4.00	3.20	2.10	3.00	2.00	1.60	.80	1.20	2.20
23	4.60	5.00	7.30	3.50	3.20	2.10	3.50	2.10	1.50	.80	1.20	2.10
24	3.90	4.60	5.80	3.40	3.20	2.00	2.50	1.90	1.40	.80	1.30	2.10
25	3.90	4.40	5.20	3.30	3.10	1.90	2.10	1.90	1.20	.80	1.90	2.00
26	4.30	5.60	4.80	3.20	2.80	2.50	2.00	2.80	1.20	.80	1.60	2.10
27	3.80	6.60	4.30	3.00	2.70	2.60	1.90	3.40	1.10	.80	1.40	13.20
28	3.50	7.70	4.00	3.20	2.60	2.50	2.30	2.60	1.10	.80	1.30	12.60
29	3.10	.....	3.90	3.00	2.50	2.00	2.60	4.60	1.00	.80	1.30	8.70
30	3.20	.....	3.90	3.00	2.50	1.80	2.40	3.20	1.00	1.20	1.30	4.20
31	3.20	.....	3.80	.....	2.40	.....	2.20	2.30	.....	1.70	.....	3.90

Oostanaula River at Resaca, Georgia, for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.50	7.00	4.70	5.30	5.20	4.10	8.00	2.60	2.90	1.90	3.50	2.10
2	3.30	6.90	4.70	5.20	4.70	4.00	5.20	2.40	2.80	1.90	3.00	2.10
3	3.40	10.20	12.30	5.30	4.60	3.80	4.90	2.30	2.80	1.90	2.70	2.30
4	3.40	8.90	12.00	5.00	4.30	3.70	4.70	2.20	2.80	1.90	2.20	2.30
5	3.40	7.20	9.30	4.70	4.20	3.70	4.00	2.20	2.80	1.90	2.20	2.20
6	3.40	6.30	6.50	4.60	4.30	6.80	3.90	2.20	2.80	1.90	2.20	2.10
7	3.80	6.40	5.80	5.60	5.30	4.80	3.90	2.40	2.70	1.90	2.10	2.10
8	8.80	7.30	5.70	15.30	6.00	3.90	8.00	5.40	2.60	1.90	2.10	2.10
9	20.20	5.20	6.00	13.30	7.70	3.70	8.10	3.80	2.60	2.10	2.10	2.30
10	23.20	5.00	5.20	10.00	7.70	3.50	7.30	3.40	2.60	2.00	2.20	3.00
11	25.80	5.00	4.90	6.70	6.00	3.40	4.90	2.80	2.60	1.90	4.20	2.90
12	26.00	4.90	5.20	5.50	8.70	3.60	4.20	4.30	2.60	2.00	3.90	2.80
13	22.70	4.80	6.00	5.50	9.00	3.80	4.00	3.70	2.60	2.00	3.20	2.50
14	14.90	4.70	13.20	5.20	7.10	3.50	3.80	3.60	2.50	2.00	2.70	2.40
15	6.50	4.70	13.80	5.20	6.00	3.40	3.60	3.20	2.40	1.90	2.40	2.30
16	6.30	4.70	12.40	6.00	5.20	3.40	3.70	3.40	2.30	1.90	2.40	2.30
17	8.10	4.70	11.50	7.80	4.80	6.90	4.00	9.20	2.50	1.90	2.30	2.20
18	7.10	4.40	8.50	6.30	4.70	5.70	3.60	7.50	3.10	1.80	2.20	2.20
19	6.00	4.40	7.20	5.70	4.60	4.20	3.20	5.60	2.70	1.80	2.20	2.20
20	5.50	5.10	12.60	5.20	4.40	3.70	3.00	5.40	2.50	1.80	2.10	2.20
21	13.40	6.20	19.80	4.90	4.20	3.50	3.00	4.50	2.30	1.70	2.20	3.50
22	12.80	6.60	19.90	4.80	4.20	3.80	3.00	6.30	2.20	1.70	2.10	5.20
23	9.90	6.20	17.80	4.70	4.10	3.70	2.90	4.60	2.10	1.70	2.10	4.40
24	7.70	5.50	13.20	4.50	3.90	3.20	2.80	4.00	2.10	1.70	2.10	3.50
25	6.40	5.00	7.70	4.50	5.30	3.10	2.70	3.80	2.10	1.70	2.10	3.10
26	7.50	4.80	7.50	5.30	6.10	3.00	3.20	3.60	2.10	1.70	2.10	3.10
27	7.60	4.70	6.70	5.70	8.60	2.90	3.20	3.30	2.80	1.70	2.10	3.60
28	6.30	4.70	6.30	6.30	7.90	2.80	2.90	4.80	2.00	1.80	2.10	4.60
29	8.00	.....	5.90	5.80	5.50	2.80	2.80	3.70	2.00	2.50	2.10	4.20
30	8.90	.....	5.60	.....	4.80	4.20	2.70	3.30	1.90	2.10	2.10	3.70
31	8.20	.....	.....	.....	4.30	.....	2.70	3.00	.....	2.20	.....	6.20

Oostanaula River at Resaca, Georgia, for 1896.

Day.	Jan.	Feb.	Mar.	Apr.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.50	3.90	3.70	4.80	2.10	1.20	6.50	1.50	9.25
2	4.60	3.90	3.70	11.80	2.30	1.25	3.70	1.40	6.70
3	4.20	4.60	3.70	11.60	2.65	1.20	2.05	1.40	4.65
4	3.80	4.80	3.60	11.70	2.40	1.25	1.65	1.35	3.90
5	3.40	4.50	3.50	6.60	2.15	1.15	1.50	1.90	3.50
6	3.00	10.70	3.40	5.40	2.00	1.15	1.40	3.15	3.20
7	2.90	16.70	3.80	5.00	1.90	1.30	1.30	2.10	3.00
8	3.30	15.50	4.20	4.90	1.80	1.10	1.30	2.00	2.90
9	4.00	15.90	3.90	4.80	1.75	1.10	1.30	2.10	3.00
10	4.00	14.10	3.60	4.30	1.75	1.05	1.20	1.85	3.50
11	3.50	9.30	3.40	4.20	1.65	1.00	1.20	1.70	3.30
12	3.40	6.90	4.50	4.00	1.65	1.00	1.20	3.00	3.10
13	3.30	5.00	4.90	3.80	1.70	1.50	1.55	13.65	2.90
14	3.10	9.10	4.00	3.70	1.60	1.25	1.65	11.35	2.80
15	3.00	9.70	3.70	3.60	1.60	1.10	1.50	11.10	4.20
16	2.90	7.80	3.60	3.60	1.70	1.05	1.45	4.25	3.90
17	3.70	6.40	6.50	3.60	1.70	1.00	1.35	3.30	3.30
18	4.00	5.70	8.40	3.50	1.70	1.00	1.30	3.00	3.00
19	3.80	5.30	6.60	3.50	1.50	.95	1.20	2.70	3.00
20	3.40	5.00	7.80	3.40	1.35	.90	1.15	2.60	2.90
21	3.20	4.70	7.10	3.30	1.30	.85	1.15	2.50	2.80
22	3.40	4.30	5.80	3.20	1.25	1.95	1.20	2.35	2.60
23	5.70	4.10	5.20	3.20	1.20	1.55	1.20	2.40	2.55
24	10.80	4.00	4.90	4.20	1.50	1.25	1.35	2.35	2.55
25	11.50	4.00	5.30	3.70	3.20	1.20	1.90	2.25	2.40
26	10.00	3.90	5.00	3.30	2.80	1.10	1.60	2.20	2.30
27	6.20	3.80	4.70	3.10	1.95	1.10	1.50	2.10	2.25
28	5.20	3.70	4.40	3.40	1.70	1.70	1.40	2.15	2.20
29	4.70	3.70	4.20	3.40	1.50	8.35	1.95	3.80	2.20
30	4.30	.....	4.00	3.30	1.40	.....	1.55	8.70	2.20
31	4.00	.....	4.60	3.10	1.30	.....	.....	.....	2.20

Coosa River at Riverside, Alabama.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1	.....	0.60	1.10	1.30	12	.....	0.60	1.60	1.55	22	.....	0.70	1.40	1.50
2	.....	1.75	1.40	2.10	13	.....	.60	2.25	1.60	23	.....	.60	1.35	1.45
3	.....	3.10	1.20	4.38	14	.....	.60	2.70	1.60	24	.....	.55	1.30	1.40
4	.....	2.75	1.10	3.80	15	.....	.55	4.00	1.80	25	.....	.60	1.25	1.35
5	.....	2.00	1.05	3.20	16	.....	.55	5.20	2.00	26	.....	.70	1.20	1.30
6	.....	1.50	1.10	2.50	17	.....	.55	4.70	2.10	27	0.45	.80	1.15	1.25
7	.....	1.20	1.20	2.20	18	.....	.65	4.20	2.20	28	.45	.85	1.15	1.20
8	.....	.85	2.55	1.90	19	.....	.80	3.20	2.00	29	.45	.90	1.10	1.10
9	.....	.70	2.30	1.70	20	.....	.85	2.30	1.80	30	.50	.95	1.20	1.10
10	.....	.60	1.90	1.60	21	.....	.75	1.50	1.70	31	.....	.85	.....	1.10
11	.....	.65	1.30	1.55										

Lock No. 4.—This point is about 3 miles above Riverside, Alabama, and no water comes into the river between these points except Blue Spring Branch, which does not furnish a cubic foot of water per second. The measurements made from the bridge of the Southern Railway at Riverside, Alabama, may therefore be used in estimating the values of gage heights observed at Lock No. 4.

A record has been kept at this point by the United States Engineer Corps, which is given below.

Coosa River at Lock No. 4, near Lincoln, Alabama, for 1890.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	8.5	20.9	17.1	3.7	3.1	1.4	2.6	3.4	3.5	3.2	1.2
2	8.5	20.2	17.6	3.4	2.7	1.4	2.0	3.1	4.6	2.9	1.2
3	7.6	19.1	16.8	3.2	2.5	1.3	1.8	2.3	4.9	2.7	1.2
4	6.4	18.2	10.4	3.2	2.4	1.3	1.8	1.6	5.9	2.5	1.2
5	5.1	17.7	11.5	3.2	2.2	1.3	2.3	1.2	6.3	2.4	1.2
6	4.5	17.9	12.1	3.2	2.3	1.3	2.3	1.0	5.4	2.3	1.3
7	4.1	17.5	11.8	3.3	2.3	1.3	2.9	1.0	4.2	2.2	2.6
8	5.4	16.7	0.2	3.3	2.2	1.2	3.0	1.0	3.9	2.1	3.3
9	7.1	13.9	8.0	3.2	2.2	1.1	2.7	1.2	4.0	2.0	5.0
10	7.8	10.3	6.8	3.1	2.4	1.1	2.6	1.2	3.9	1.9	6.4
11	7.9	7.8	6.0	3.0	2.8	1.0	2.9	1.3	3.9	1.8	6.2
12	7.5	6.5	5.5	2.8	3.9	1.0	2.5	1.6	3.4	1.7	5.0
13	6.6	5.9	5.1	2.7	3.7	1.0	2.7	1.4	2.8	1.7	4.8
14	5.7	6.8	4.7	2.7	3.8	1.0	2.7	1.1	2.4	1.7	2.9
15	5.4	8.7	4.3	2.7	2.5	.9	2.0	1.0	2.2	1.6	2.5
16	5.5	9.2	4.1	3.2	2.2	.9	1.6	1.0	2.2	1.5	2.3
17	5.6	8.7	5.1	3.7	2.2	1.2	1.9	1.4	2.6	1.5	2.0
18	5.4	7.9	5.6	4.2	2.1	1.4	2.2	1.4	3.2	1.6	1.9
19	4.7	7.1	5.8	4.0	2.0	1.4	1.9	1.1	4.7	1.7	1.9
20	4.3	8.5	6.3	4.0	1.9	1.2	1.6	.9	4.9	1.7	2.0
21	3.9	10.5	5.7	3.9	2.3	1.1	1.4	.9	3.8	1.7	2.0
22	3.6	11.4	5.0	3.6	2.1	1.1	1.2	.9	3.6	1.7	1.9
23	3.5	14.4	4.3	4.0	1.9	1.1	1.0	1.1	8.9	1.5	1.8
24	5.2	14.2	3.9	4.1	1.8	1.1	.9	1.9	11.0	1.4	1.7
25	11.6	14.0	3.8	3.6	1.8	1.2	.9	5.1	11.5	1.3	1.7
26	16.4	13.4	3.7	3.1	1.7	1.5	.9	6.1	10.9	1.3	2.7
27	18.6	12.1	3.8	3.1	1.5	3.2	.9	6.0	8.9	1.3	4.6
28	.....	10.0	3.8	3.4	1.5	5.2	1.1	4.5	6.6	1.3	5.0
29	.....	7.9	3.8	3.4	.....	4.3	1.7	4.0	5.0	1.2	5.4
30	.....	6.4	3.7	5.1	.....	3.1	2.5	3.4	4.0	1.2	5.3
31	.....	6.0	.....	4.0	.....	2.8	.....	.....	3.6	.....	4.4

Coosa River at Lock No. 4, for 1891.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.6	13.7	10.0	12.2	3.9	2.8	1.6	8.6	1.5	0.4	0.1	1.5
2	5.4	13.8	8.3	13.5	3.6	2.4	1.5	10.8	1.3	.4	.1	1.3
3	6.6	14.4	7.5	13.8	3.5	2.2	1.5	11.7	1.3	.5	.1	1.0
4	7.5	15.1	7.0	13.5	3.5	2.2	1.5	11.3	1.4	.4	.1	1.0
5	7.6	14.9	6.7	12.3	3.4	2.0	1.4	9.9	1.6	.3	.1	2.4
6	6.7	14.5	9.1	9.9	3.3	2.0	1.4	7.0	2.8	.3	.1	3.3
7	5.2	16.3	12.7	8.0	3.1	2.0	1.3	6.2	3.8	.4	.1	5.1
8	4.1	16.7	16.2	7.0	3.0	2.1	2.0	4.7	3.0	.3	.1	5.8
9	3.6	16.0	18.9	6.5	2.9	2.4	2.5	3.4	1.9	.3	.1	6.4
10	3.4	19.0	18.9	6.0	2.8	6.6	2.6	2.7	1.6	.3	.4	5.9
11	3.7	18.8	18.3	5.8	2.8	5.6	3.8	2.4	2.1	.4	.3	4.4
12	4.9	18.3	18.2	5.7	2.8	3.9	4.0	2.2	1.6	.5	.4	3.0
13	6.5	19.2	18.1	5.6	2.8	3.3	3.6	2.2	1.4	.4	.6	3.0
14	6.5	19.4	18.0	5.5	2.7	3.9	2.8	2.1	1.6	.3	1.7	2.5
15	6.6	19.0	17.8	5.2	2.6	3.5	2.2	2.0	2.7	.3	1.0	2.0
16	5.7	18.4	17.6	5.2	2.6	3.1	1.7	1.9	2.6	.3	.7	3.2
17	5.4	18.1	17.4	5.1	2.8	2.8	1.5	1.7	2.1	.3	.6	4.6
18	5.4	17.6	16.4	4.9	2.7	2.8	1.5	1.6	1.6	.3	.5	5.4
19	5.6	16.9	15.1	4.9	2.7	2.9	1.6	1.6	1.3	.3	.5	4.8
20	5.3	16.2	11.3	4.9	2.8	3.0	1.5	1.6	1.0	.2	.5	3.8
21	4.9	16.2	8.1	5.1	2.8	3.8	1.8	1.7	.9	.2	.5	3.2
22	6.8	16.0	7.1	4.7	3.1	4.4	2.4	1.6	.8	.2	1.0	2.4
23	8.3	14.9	6.7	4.5	3.6	3.4	2.0	1.7	.7	.1	1.1	2.1
24	9.3	14.7	6.4	5.0	2.8	3.0	1.8	1.5	.7	.1	1.1	2.2
25	10.3	14.7	6.2	6.7	2.6	3.0	1.7	1.6	.6	.1	3.3	2.0
26	10.1	14.4	6.3	6.7	2.6	2.8	1.9	1.7	.6	.1	3.4	3.0
27	9.5	13.7	8.1	6.0	2.9	2.4	2.0	2.4	.7	.1	3.2	3.5
28	8.5	11.9	8.8	5.2	3.0	2.0	1.9	2.0	.5	.1	2.1	4.0
29	9.0	.....	9.3	4.6	3.2	1.8	2.3	1.5	.5	.1	2.0	4.1
30	11.0	.....	8.9	4.1	3.2	1.7	3.2	1.5	.5	.1	1.7	4.0
31	11.4	.....	10.4	.....	3.0	.....	2.9	1.5	.....	.1	.....	3.8

Coosa River[1] *at Lock No. 4, for 1892.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.3	4.3	3.9	6.8	4.9	2.3	4.3	2.0	2.8	1.2	0.4	3.2
2	4.3	4.1	3.8	5.9	4.8	2.1	3.4	1.9	2.4	1.2	.4	2.8
3	5.8	4.0	3.6	5.5	4.6	2.5	2.5	1.8	2.2	1.2	.3	2.4
4	6.0	3.8	3.5	5.0	4.2	2.8	2.1	1.8	1.8	1.0	.4	2.4
5	5.2	3.8	3.3	4.7	3.8	3.5	2.0	1.7	1.5	.9	.5	2.7
6	4.6	3.7	3.2	6.6	3.6	5.1	2.1	1.7	1.4	.9	.5	2.4
7	4.2	3.7	4.0	20.8	3.5	5.5	2.1	1.6	1.3	.8	1.0	2.4
8	4.6	3.9	5.8	23.7	3.3	4.7	3.3	1.5	1.2	.8	1.0	2.8
9	5.0	4.6	8.0	23.4	3.3	3.8	5.6	1.5	1.2	.7	1.0	2.3
10	5.5	4.8	9.8	22.5	3.3	3.6	6.4	1.4	1.1	.7	1.2	2.2
11	5.8	5.0	10.4	22.3	3.5	3.5	6.3	1.4	1.0	.7	3.2	2.9
12	7.8	4.7	9.5	22.7	3.6	3.0	8.7	1.6	.9	.8	6.9	2.5
13	16.3	4.2	7.2	23.0	4.0	3.4	10.6	1.9	1.0	.8	6.9	2.4
14	19.3	3.8	5.8	22.6	4.0	3.0	10.9	1.7	.9	.8	4.7	2.1
15	19.7	3.8	4.9	21.6	3.6	2.5	11.3	1.6	.9	.7	3.9	2.4
16	19.1	3.9	4.5	20.0	3.3	2.2	9.4	1.5	1.0	.8	3.1	2.8
17	18.8	3.9	4.2	18.4	3.0	2.0	7.5	1.5	3.3	.8	.....	3.1
18	19.6	4.0	4.0	14.4	2.8	1.9	6.0	1.5	1.9	.8	6.0	4.4
19	21.5	4.1	5.9	8.5	3.5	1.8	5.5	1.4	1.3	.7	4.8	5.5
20	23.1	3.9	6.1	6.1	3.3	1.9	8.1	1.9	1.3	.5	4.0	6.9
21	23.4	4.2	5.9	6.0	3.7	2.1	6.4	2.1	1.9	.5	4.2	8.9
22	22.8	5.3	5.4	8.3	4.4	2.4	6.3	2.3	3.2	.5	3.9	9.2
23	22.1	7.2	5.2	8.4	3.8	4.4	5.3	2.4	5.5	.5	3.2	9.5
24	21.3	8.4	7.1	7.1	3.4	3.9	5.3	.....	5.8	.5	2.6	8.1
25	20.0	8.0	7.8	6.1	3.3	3.9	4.6	5.4	4.1	.5	2.2	6.3
26	18.9	6.6	9.4	5.8	3.3	3.3	3.8	7.0	3.3	.4	1.9	5.1
27	16.6	5.0	10.8	5.3	2.9	4.0	3.3	6.8	2.3	.5	1.8	4.2
28	11.0	4.6	11.4	4.8	2.8	4.1	3.0	5.1	1.8	.5	1.7	3.7
29	6.7	4.3	11.8	4.6	2.7	4.2	2.8	4.2	1.5	.5	1.9	3.3
30	5.4	.....	11.1	4.8	2.6	4.5	2.5	3.7	1.3	.4	3.3	2.9
31	4.5	.....	8.9	.....	2.5	.....	2.1	3.2	.....	.4	.....	2.6

Coosa River[1] *at Lock No. 4, for 1893.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.7	5.6	7.1	3.6	4.5	5.4	1.9	1.0	.2	0.3	—0.1	0.3
2	2.8	5.0	7.9	3.5	5.2	7.4	1.8	.9	.2	.3	— .1	.3
3	3.1	4.4	8.1	3.3	9.7	7.9	1.7	1.1	.3	.3	— .1	.9
4	3.1	3.8	7.9	3.2	14.4	8.0	1.7	1.4	1.2	.3	— .1	1.0
5	3.3	3.5	8.4	3.4	15.1	8.0	1.6	1.4	1.7	.2	.0	1.2
6	3.0	3.3	8.2	3.5	12.5	7.3	1.8	1.8	1.1	.2	.0	1.3
7	2.8	3.1	7.6	3.7	12.5	7.3	1.6	1.6	1.6	.2	.0	1.5
8	2.5	3.1	6.6	3.8	10.5	9.3	1.5	1.5	.5	.3	.0	1.2
9	2.2	3.1	7.7	4.0	9.8	10.4	1.5	1.5	.5	.3	.0	.7
10	2.1	3.0	8.8	3.8	7.9	10.2	1.4	1.4	.4	.3	.0	.6
11	1.9	3.8	10.1	3.3	6.4	7.9	1.5	1.5	.5	.1	— .1	.4
12	2.1	6.5	10.5	3.0	5.6	5.6	1.4	1.4	.8	.1	.0	.3
13	2.0	9.2	9.8	2.9	4.9	4.2	1.4	1.0	1.5	.1	.0	.3
14	2.0	11.3	8.0	3.3	4.4	3.6	1.3	1.4	2.7	.1	.0	.3
15	2.1	12.1	6.9	4.0	3.9	3.1	1.2	1.3	3.3	.0	.0	.3
16	2.6	20.8	5.9	4.4	3.7	3.0	1.3	1.1	3.5	.0	+ .1	.5
17	2.4	20.6	5.3	4.4	3.5	2.9	1.2	1.2	3.0	.0	.0	.6
18	2.1	19.5	4.8	4.3	3.2	2.6	1.1	1.3	2.1	.0	.0	6
19	2.1	18.4	4.5	3.9	3.1	2.5	1.0	1.4	1.5	.0	.0	.9
20	2.0	17.8	4.2	3.3	3.0	2.9	.9	1.1	1.0	.0	.0	.7
21	2.0	17.3	4.0	3.6	2.8	2.8	1.0	1.0	.7	.0	.1	.7
22	2.0	16.8	3.8	3.8	2.6	2.4	.9	.8	.6	.0	.1	.6
23	2.0	15.9	3.7	3.7	2.5	3.0	.9	.5	.5	.0	.1	.4
24	2.1	14.0	3.9	3.6	2.3	3.1	.9	.4	.4	.0	.2	.3
25	2.8	9.4	5.9	3.3	2.2	2.9	1.3	.3	.3	.0	.2	.3
26	3.7	6.5	6.0	3.1	2.1	3.8	1.5	.3	.3	.0	.1	.2
27	4.7	5.5	5.8	4.8	2.0	3.7	1.2	.4	.4	.0	.3	.1
28	5.5	6.2	5.4	6.4	2.0	3.4	.8	.2	.2	.0	.3	.1
29	5.8	.....	4.2	5.9	3.0	2.0	.7	.1	.1	.0	.2	.9
30	5.8	.....	4.0	5.4	5.4	1.9	.7	.2	.2	.0	.1	.2
31	5.7	.....	3.7	.....	6.0	.....	1.0	.2	.....	.0	.....	.....

[1] Record from United States Engineer Office.

Coosa River[1] *at Lock No. 4, for 1894.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.3	2.1	7.4	2.8	1.7	0.7	0.7	0.9	1.4	0.1	—0.1	0.0
2	1.5	2.0	7.6	3.4	1.7	.7	.5	1.0	1.4	—.1	—.2	—.1
3	1.3	2.0	7.6	4.3	1.6	.6	.3	1.0	1.0	—.1	—.1	—.2
4	1.3	2.0	6.9	3.9	1.6	.6	.3	1.0	.8	—.3	.0	—.1
5	1.2	2.8	6.0	3.7	1.7	.5	.3	.7	.5	—.4	+.1	—.2
6	1.2	4.1	5.2	3.9	1.8	.5	.3	.7	.2	—.3	.0	—.2
7	2.5	5.0	4.6	2.7	1.7	.4	1.0	1.2	.1	—.2	—.1	—.3
8	4.1	5.2	4.2	.....	1.4	.4	1.0	1.2	.1	—.2	—.1	—.1
9	4.1	6.0	3.9	.....	1.4	.4	.8	.8	.1	—.2	—.2	.0
10	7.6	6.2	3.7	.....	1.4	.3	.8	.5	.1	—.1	—.3	+.1
11	9.3	6.3	3.4	.....	1.5	.3	1.3	.3	.0	—.3	—.3	.3
12	9.3	6.8	3.9	.....	2.2	.2	1.1	.2	.3	—.3	—.3	1.5
13	8.1	8.3	5.6	.....	1.9	.2	.5	.2	.4	—.2	—.4	6.0
14	6.8	8.9	5.6	.....	1.9	.2	.3	.2	.7	—.1	—.3	9.6
15	5.4	9.1	5.1	4.1	2.0	.1	.2	.1	.5	—.1	—.2	10.0
16	5.1	8.3	5.1	3.1	2.4	.1	.1	.1	.5	—.1	—.2	8.0
17	4.9	6.7	5.9	2.8	2.8	.1	.1	.1	.4	—.1	—.1	5.0
18	4.8	5.8	5.3	2.8	3.0	.3	.1	.2	.4	—.2	—.1	2.9
19	4.9	5.7	4.8	2.6	2.4	.3	.2	.1	1.4	—.3	.0	2.0
20	4.5	5.9	4.6	3.1	1.7	.7	.6	.6	3.9	—.4	.0	1.6
21	3.9	6.5	7.1	2.8	1.4	.8	1.6	.5	3.1	—.4	.0	1.4
22	4.0	6.6	8.7	3.0	1.4	.9	1.4	.2	2.9	—.3	.0	1.3
23	4.4	6.6	9.2	3.0	1.4	1.0	1.2	.3	1.3	—.4	.0	1.1
24	4.1	6.3	8.3	2.9	1.2	.9	1.4	1.9	.8	—.4	.0	.8
25	3.9	5.2	7.3	2.5	1.2	1.2	1.8	2.6	.5	—.3	.0	.7
26	3.5	5.5	5.8	2.1	1.2	2.4	2.1	2.0	.3	—.3	.0	1.0
27	3.1	5.9	4.7	2.0	1.2	2.4	1.4	1.8	.2	—.3	+.1	4.9
28	2.8	5.6	4.0	2.0	1.2	1.2	.9	1.5	.2	—.3	.4	6.9
29	2.7	.....	3.6	1.7	.9	1.0	1.9	3.7	.1	—.4	.2	8.4
30	2.5	.....	3.3	1.7	.9	.8	1.3	2.4	.2	—.1	.1	8.5
31	2.2	.....	3.0	.....	.8	.....	.9	1.6	.....	—.1	.....	6.8

Coosa River[1] *at Lock No. 4, for 1895.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.5	8.4	4.4	5.6	5.2	4.8	2.2	1.6	3.3	0.8	0.9	0.9
2	3.0	8.0	6.1	5.4	5.2	4.0	2.6	1.5	3.1	.8	1.0	.9
3	2.5	9.0	8.2	5.0	4.8	3.8	4.0	1.5	2.7	.8	1.1	.9
4	2.3	9.2	9.4	4.8	4.4	3.6	4.8	1.5	2.6	.8	1.4	.8
5	2.3	9.4	9.8	4.6	4.8	3.4	5.4	1.4	4.1	.8	1.6	.8
6	2.4	8.6	9.0	4.2	4.4	3.4	4.8	1.3	3.1	.8	1.2	.8
7	2.5	8.0	8.0	5.4	4.4	3.4	3.2	1.3	2.8	.8	1.0	.9
8	5.4	7.0	7.5	9.6	5.0	4.0	3.0	1.3	2.8	.9	.9	.9
9	12.4	6.6	6.2	11.6	5.7	4.6	2.8	1.3	2.8	.8	.8	.9
10	15.7	8.8	5.8	12.0	5.8	3.8	2.6	1.4	2.5	.8	.9	.9
11	16.1	7.8	5.4	11.2	6.0	3.4	2.4	1.5	2.1	.7	1.0	.9
12	15.6	5.0	5.4	9.4	5.6	3.0	2.8	1.4	2.0	.9	1.1	.9
13	15.7	5.0	5.4	7.2	5.0	3.0	2.2	1.2	1.8	.9	1.4	1.2
14	15.3	5.2	8.0	5.8	5.0	3.0	3.5	2.0	1.7	.8	1.9	1.2
15	15.1	4.6	11.6	5.2	5.2	3.6	3.3	3.0	1.7	.8	2.0	1.2
16	15.0	4.4	15.6	5.0	5.0	3.4	3.4	2.7	1.6	.8	1.6	1.1
17	15.0	4.2	16.4	5.6	4.4	3.2	3.3	3.1	1.5	.8	1.3	1.0
18	12.4	4.4	13.6	6.2	4.0	3.0	3.1	4.0	1.5	.7	1.1	1.0
19	8.9	4.4	14.6	8.2	4.0	3.0	2.8	7.5	1.7	.7	1.0	.9
20	6.9	4.6	13.4	8.8	3.8	3.6	2.6	8.3	1.7	.7	1.0	.9
21	6.8	5.0	14.2	7.6	3.6	4.0	2.4	6.5	1.7	.6	.9	1.1
22	10.3	5.6	14.4	6.0	3.4	3.2	2.3	7.9	1.6	.6	.9	1.2
23	11.5	5.8	14.6	5.4	3.0	3.4	2.3	7.7	1.4	.6	.8	1.5
24	11.3	5.8	14.0	4.8	3.2	3.0	2.0	7.0	1.3	.6	.8	1.8
25	10.0	5.8	13.6	4.6	3.4	2.8	2.1	5.6	1.2	.6	.8	2.5
26	9.8	5.2	13.0	4.4	5.0	2.6	2.0	4.2	1.1	.6	.8	2.5
27	9.4	5.0	9.8	4.4	6.4	2.4	1.8	3.4	1.1	.6	.9	2.5
28	9.0	4.6	7.4	5.0	9.0	2.8	1.8	3.2	1.0	.7	.8	2.5
29	9.4	.....	6.2	5.6	9.0	2.2	1.9	3.2	1.0	.7	.8	2.5
30	9.2	.....	6.0	5.6	7.8	2.0	1.8	4.0	.9	.7	.8	2.5
31	9.0	.....	5.4	.....	6.0	.....	1.7	3.4	.....	.8	.....	2.8

[1] Record from United States Engineer Office.

Coosa River[1] *at Lock No. 4, for 1896.*

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.0	3.8	3.4	3.5	2.5	0.1	0.6	1.3	0.6	0.2	0.7	1.5
2	4.1	3.8	3.3	5.2	2.4	.1	.5	1.1	.5	2.0	1.2	2.8
3	4.1	3.4	3.0	7.0	2.2	.1	.5	1.2	.3	3.5	1.0	4.7
4	3.5	3.5	2.8	8.5	2.1	.1	.5	1.4	.2	3.0	.6	5.6
5	3.5	3.5	2.8	7.3	2.8	.2	.4	1.4	.2	2.9	.5	3.3
6	2.6	6.5	2.7	7.3	2.9	.2	.5	1.4	.1	1.1	.5	2.7
7	2.1	10.0	3.0	6.8	2.9	.1	1.0	1.2	.1	.6	.5	2.2
8	2.0	11.8	3.1	5.0	2.7	.1	2.7	1.0	.1	.5	2.5	1.9
9	1.8	13.7	3.0	4.1	2.4	.1	4.7	.9	.1	.4	2.5	1.7
10	1.9	13.4	2.9	3.6	2.1	.1	6.2	.7	.0	.3	1.7	1.6
11	2.1	13.0	3.4	3.6	1.8	.2	7.5	.5	.0	.3	1.1	1.5
12	2.4	11.8	4.7	3.6	1.8	.2	7.0	.5	.0	.2	1.3	1.4
13	2.3	10.0	5.2	3.0	1.5	.1	4.8	.5	.0	.2	2.2	1.5
14	2.0	8.7	4.8	2.9	1.4	.1	2.8	.5	.1	.2	2.6	1.5
15	1.8	7.8	4.4	2.7	1.3	.1	2.6	1.0	.0	.2	4.4	1.6
16	1.8	7.6	4.1	2.5	1.2	.1	2.4	.6	.0	.2	6.0	1.4
17	2.8	7.6	5.0	2.5	1.2	.1	2.8	.5	.0	.1	5.4	1.7
18	3.4	6.8	5.8	2.4	1.2	.1	2.8	.5	.0	.1	4.4	2.0
19	4.1	6.0	6.8	2.4	1.1	.1	3.3	.5	.0	.2	3.8	2.0
20	4.0	5.2	7.7	2.2	1.1	.1	3.9	.5	.1	.2	1.8	1.7
21	3.6	4.5	8.0	2.1	1.1	.1	3.4	.4	.1	.2	1.4	1.4
22	4.4	4.1	7.4	2.0	1.0	.1	2.6	.4	.0	.2	1.3	1.8
23	6.9	3.9	6.5	2.0	1.1	.1	2.2	.4	.0	.1	1.1	1.3
24	9.0	3.5	5.7	2.0	1.4	.1	2.0	.4	.0	.1	1.0	1.3
25	9.6	3.3	5.2	2.0	.9	.1	1.9	.5	.0	.1	.9	1.1
26	10.0	3.2	4.8	2.2	1.2	.1	2.0	.4	.1	.1	.9	1.0
27	10.0	3.0	4.3	2.5	1.5	.....	2.0	.5	.1	.2	.9	1.0
28	8.7	3.0	4.0	2.7	1.5	.....	1.9	.7	.0	.2	.9	.9
29	7.8	3.0	4.0	2.4	1.3	.....	1.5	.9	.1	.5	.9	.9
30	5.2	.....	3.6	2.2	1.5	.....	1.3	.8	.2	.5	1.3	.8
31	4.4	.....	3.4	.....	1.4	.....	1.2	.7	.....	.5	.....	.8

[1] Record from United States Engineer Office.

Lock No. 5.—This is a site for a proposed lock to improve the navigation of the Coosa River. It is about 6 miles below the crossing of the Southern Railway at Riverside, Alabama. Blue Eye Creek and Choccolocco Creek flow into the river between Riverside and Lock No. 5.

The record of gage heights furnished by the United States Engineer Corps is presented below:

Coosa River at Lock No. 5, Georgia, for 1892.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.0	2.9	2.5	4.9	3.0	1.3	2.6	1.0	1.5	0.8	0.2	1.9
2	2.8	2.7	2.4	4.0	2.9	1.3	2.7	1.0	1.5	.7	.2	1.6
3	3.3	2.5	2.3	3.6	2.8	1.5	1.5	1.0	1.3	.5	.2	1.4
4	3.7	2.4	2.1	3.3	2.8	1.6	1.2	.9	1.0	.5	.3	1.3
5	3.8	2.3	2.0	3.0	2.5	1.6	1.1	1.0	1.0	.5	.4	1.1
6	3.3	2.2	1.9	3.0	2.2	2.6	1.1	1.0	.8	.5	.3	1.5
7	2.5	2.1	2.1	16.8	2.1	3.1	1.0	.9	.8	.4	.5	1.4
8	2.2	2.5	3.4	19.4	1.9	2.9	.....	.8	.8	.4	.8	1.5
9	2.5	3.1	5.4	18.2	2.1	2.3	3.4	.8	.7	.4	2.0	1.9
10	3.5	3.0	6.7	17.2	2.2	2.2	4.3	.8	.7	.4	1.8	2.0
11	3.8	3.2	7.2	17.1	2.3	2.0	4.0	.9	.6	.4	3.5	1.5
12	4.4	3.0	6.7	17.4	2.4	1.8	5.7	.9	.6	.4	4.5	1.6
13	13.0	2.9	5.0	17.1	2.5	1.5	7.3	1.0	.5	.4	3.8	1.3
14	16.5	2.8	3.7	16.8	2.3	2.0	7.6	.9	.5	.4	2.7	1.2
15	15.8	2.3	3.0	16.1	2.1	1.4	8.0	.9	.5	.4	2.1	1.6
16	14.8	2.4	2.7	15.0	2.0	1.2	7.0	.8	.6	.4	1.9	1.8
17	14.2	2.4	2.6	13.6	1.9	1.1	5.1	.8	1.0	.4	2.0	2.1
18	14.4	2.5	2.4	9.5	1.9	1.1	4.0	.9	.8	.4	1.7	2.4
19	16.7	2.5	3.8	6.3	2.1	1.1	3.5	.8	1.3	.3	1.7	3.4
20	18.4	2.4	4.0	4.1	2.0	1.1	5.0	.8	1.7	.3	2.1	4.4
21	18.4	2.7	3.9	3.7	2.2	1.3	4.5	.9	2.0	.3	2.0	6.1
22	17.3	3.4	3.5	5.7	2.4	2.3	3.5	.9	2.5	.3	1.7	6.6
23	16.5	4.6	3.1	5.7	2.3	2.5	3.4	1.3	3.8	.3	1.7	6.4
24	15.7	5.6	4.9	4.9	2.0	2.3	3.6	1.7	3.8	.3	1.5	5.5
25	14.6	5.4	5.7	4.0	1.9	.....	3.2	3.4	2.4	.3	1.3	4.5
26	13.8	4.5	7.2	3.7	2.0	2.1	3.0	4.3	2.0	.3	1.1	3.1
27	12.2	3.5	8.7	3.3	1.7	2.2	2.8	4.7	1.4	.2	1.2	2.7
28	7.5	3.1	8.7	3.0	1.5	2.4	2.3	3.5	1.2	.2	1.1	2.4
29	4.5	2.7	8.6	2.8	1.5	2.4	1.5	2.7	.9	.2	1.3	1.9
30	3.4	.....	8.0	3.0	1.5	2.7	1.3	2.1	.8	.2	1.8	1.6
31	3.0	.....	6.9	.....	1.5	.....	1.1	2.0	.....	.2	.....	1.5

Coosa River at Lock No. 5, Georgia, for 1893.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.4	5.0	2.1	2.8	4.7	1.1	0.5	0.2	0.3	0.0	0.2
2	.....	3.0	5.1	2.1	3.5	5.5	1.0	.5	.3	.3	.0	.3
3	.....	2.6	5.6	2.0	6.3	5.9	1.0	.5	.3	.3	.0	.3
4	.....	2.4	5.6	1.9	0.9	5.2	1.0	.6	.5	.3	.0	.3
5	.....	2.1	6.1	2.1	11.5	5.1	1.0	.8	.9	.3	.0	.5
6	.....	2.0	5.9	2.2	10.6	5.0	1.0	1.1	.7	.3	.1	.6
7	.....	1.8	4.6	2.3	19.1	5.0	1.0	1.4	.4	.2	.1	1.0
8	1.5	1.8	4.6	2.3	7.6	6.2	.9	1.7	.3	.2	.1	1.0
9	1.3	1.8	5.7	2.3	6.3	7.2	.8	1.8	.3	.2	.1	.8
10	1.2	1.9	6.4	2.2	5.7	7.2	.8	1.2	.3	.2	.1	.8
11	1.2	2.3	7.3	2.0	4.6	4.9	.7	.8	.5	.1	.1	.5
12	1.2	4.7	7.5	1.8	3.7	3.9	.7	.8	.9	.1	.1	.3
13	1.1	7.1	6.4	1.8	3.2	2.7	.7	.8	1.6	.1	.1	.3
14	1.2	8.0	5.6	2.0	2.7	2.2	.6	1.0	1.9	.1	.1	.3
15	1.2	12.3	4.6	2.2	2.6	2.0	.6	1.0	1.9	.1	.1	.3
16	1.3	18.1	4.0	2.6	2.3	1.7	.6	.8	2.0	.1	.1	.3
17	1.5	17.4	3.4	2.7	2.1	1.6	.6	.8	1.8	.1	.1	.3
18	1.5	15.3	3.1	2.7	2.0	1.6	.6	.9	1.6	.1	.1	.3
19	1.9	14.0	2.9	2.7	2.0	1.5	.5	.....	1.0	.1	.1	.3
20	1.7	13.7	2.6	2.2	2.0	1.4	.5	.7	.7	.1	.1	.4
21	1.6	12.9	2.5	2.3	1.8	1.4	.5	.6	.5	.1	.1	.4
22	1.5	12.4	2.4	2.4	1.7	1.5	.5	.4	.4	.1	.2	.5
23	1.1	10.4	2.3	.....	1.6	1.5	.5	.3	.4	.1	.2	.4
24	1.3	9.7	2.3	.....	1.4	1.9	.5	.3	.4	.0	.2	.4
25	1.3	7.5	3.8	.....	1.3	1.8	.5	.3	.3	.0	.2	.4
26	1.7	4.4	3.9	.....	1.3	1.9	.5	.2	.3	.0	.2	.3
27	2.0	3.6	3.7	.....	1.2	2.7	.5	.3	.3	.0	.2	.3
28	2.9	4.5	3.4	.....	2.8	2.1	.5	.2	.2	.0	.3	.2
29	3.9	.....	2.8	.....	3.4	1.5	.6	.2	.2	.0	.3	.2
30	3.9	.....	2.4	3.6	3.5	1.2	.5	.2	.2	.0	.2	.5
31	3.8	.....	2.3	.....	3.5	.....	.5	.2	.....	.0	.....	1.1

Coosa River at Lock No. 5, Georgia, for 1894.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.4	1.3	5.0	1.8	1.1	0.5	0.5	0.5	0.8	0.0	0.2	0.2
2	1.1	1.2	5.3	2.0	1.0	.5	.4	.5	1.0	.0	.2	.1
3	1.1	1.2	5.2	2.8	1.0	.5	.3	.6	.8	.1	.2	.1
4	1.0	1.3	4.5	2.6	1.0	.5	.3	.7	.5	.2	.1	.1
5	.9	1.7	4.0	2.2	1.0	.4	.2	.6	.3	.2	.1	.1
6	.8	2.3	3.4	2.3	1.0	.4	.2	.5	.2	.2	.1	.1
7	1.5	3.1	3.0	2.4	1.0	.4	.6	.5	.2	.2	.1	.1
8	2.9	3.2	2.7	2.2	1.0	.3	.7	.8	1.3	.2	.1	.1
9	2.8	3.7	2.6	2.0	.8	.3	.7	.6	.2	.2	.1	.1
10	5.7	4.3	2.5	2.5	.8	.3	.8	.5	.3	.2	.1	.3
11	7.4	4.2	2.1	3.3	.8	.3	.9	.4	.3	.2	.0	.5
12	7.5	4.7	3.2	3.1	1.7	.2	.6	.2	.6	.2	.0	2.4
13	6.0	6.1	3.5	3.0	1.3	.2	.4	.2	.8	.2	.0	3.8
14	4.6	6.3	3.8	3.1	1.3	.2	.3	.2	.7	.2	.0	6.7
15	3.6	6.4	3.3	2.7	1.3	.2	.3	.2	.5	.2	.0	7.0
16	3.6	5.7	3.4	2.3	1.5	.2	.3	.1	.3	.2	.0	5.7
17	3.3	4.6	4.5	2.0	1.7	.1	.2	.1	.3	.2	.0	3.6
18	3.3	4.3	3.9	1.7	1.8	.2	.2	.1	.8	.2	.1	1.9
19	3.3	3.6	3.2	1.6	1.5	.3	.2	.1	1.0	.2	.1	1.2
20	2.9	3.7	3.0	2.0	1.5	.4	.4	.1	1.7	.2	.1	1.0
21	2.5	4.3	5.3	1.9	1.0	.5	.8	.1	2.3	.3	.1	.9
22	2.4	4.6	6.3	1.9	1.0	.6	.9	.3	1.8	.3	.1	.8
23	2.6	4.1	6.9	2.0	1.0	.6	.7	.3	1.0	.3	.1	.6
24	2.5	3.4	6.3	1.8	.9	.5	.8	1.7	.6	.3	.1	.5
25	2.4	3.5	5.3	1.6	.8	.8	.9	1.5	.3	.3	.1	.5
26	2.1	4.0	4.0	1.4	.8	1.5	1.1	1.7	.3	.3	.2	.6
27	1.9	4.0	3.2	1.3	.8	1.4	.9	1.2	.2	.3	.2	3.2
28	1.7	4.4	2.7	1.2	.7	1.0	.5	.7	.2	.2	.3	4.5
29	1.6	.....	2.3	1.2	.7	.7	1.2	2.2	.1	.2	.2	5.5
30	1.5	.....	2.1	1.1	.6	.5	1.0	1.6	.1	.2	.2	5.7
31	1.4	.....	1.9	.....	.5	.....	.6	1.2	.....	.2	.....	4.6

Coosa River[1] *at Lock No. 5, Georgia, for 1895.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.0	5.8	2.2	3.0	3.0	2.7	1.9	0.6	1.6	0.3	0.1	0.3
2	1.9	5.6	3.5	2.9	2.8	2.1	2.2	.6	1.5	.3	.1	.3
3	1.5	6.3	5.8	2.7	2.7	1.9	3.4	.6	1.4	.2	.1	.3
4	1.4	6.4	6.8	2.5	3.8	1.6	4.2	.5	1.3	.2	.4	.3
5	1.4	6.5	7.0	2.4	2.8	1.5	4.5	.4	2.1	.2	.7	.3
6	1.4	6.0	6.4	2.3	2.5	1.5	5.7	.4	1.6	.2	.6	.3
7	1.4	5.2	5.5	2.1	2.4	1.6	2.9	.4	1.4	.2	.5	.3
8	3.9	4.8	4.6	6.8	2.9	1.9	2.6	.5	1.3	.2	.3	.2
9	10.5	4.4	4.0	8.5	3.5	2.3	4.1	.5	1.2	.2	.2	.2
10	12.9	4.0	3.5	8.7	3.5	1.9	5.4	.6	.9	.2	.2	.2
11	12.6	3.5	3.3	8.0	3.7	1.3	6.0	1.0	.9	.2	.5	.2
12	12.0	3.0	3.3	6.9	3.7	1.3	5.2	1.1	.8	.2	.6	.2
13	11.4	2.9	3.3	5.0	3.5	1.4	3.4	1.0	.8	.2	.7	.3
14	11.3	2.8	5.1	3.6	2.9	1.4	3.4	1.3	.7	.2	.7	.5
15	11.3	2.5	8.5	3.0	3.0	1.4	1.9	1.5	.6	.2	.9	.5
16	11.3	2.3	13.8	2.8	2.9	1.3	2.0	1.3	.6	.2	.7	.5
17	11.4	2.2	13.6	3.4	2.4	1.3	1.8	1.5	.6	.1	.6	.5
18	9.5	2.2	12.5	4.0	2.0	1.3	1.5	2.0	.6	.1	.5	.5
19	6.5	2.2	11.3	5.5	1.9	1.4	1.4	4.0	.7	.1	.5	.5
20	4.8	2.5	10.3	6.1	1.7	1.5	1.2	5.1	.8	.1	.4	.5
21	4.4	2.9	10.8	5.1	1.7	2.4	1.2	4.0	.7	.1	.3	.5
22	6.9	3.2	10.7	3.8	1.6	1.7	1.0	5.1	.6	.1	.3	.6
23	8.1	3.4	10.9	3.1	1.5	1.7	1.0	5.2	.5	.1	.3	.7
24	7.0	3.5	10.6	2.7	1.4	1.1	1.0	4.6	.5	.1	.3	.8
25	6.8	3.1	10.0	2.5	1.5	1.1	1.0	3.5	.4	.1	.3	.8
26	7.1	2.7	9.0	2.3	2.0	1.2	.9	2.4	.3	.1	.3	1.1
27	6.8	2.5	7.2	2.4	3.6	1.1	.8	1.8	.3	.1	.3	1.2
28	6.5	2.3	5.1	2.6	5.6	1.0	.8	1.6	.3	.1	.3	1.2
29	6.7	.....	4.0	3.3	6.2	.9	.8	1.6	.3	.1	.3	1.3
30	6.5	.....	3.6	3.8	5.3	1.9	.8	2.1	.3	.1	.3	1.4
31	6.3	.....	3.3	.....	3.8	.....	.7	1.9	.....	.1	.3	1.6

Coosa River[1] *at Lock No. 5, Georgia, for 1896.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.0	2.1	1.8	1.7	1.1	0.7	0.1	0.4	0.1	0.3	0.1	0.6
2	2.1	1.9	1.7	2.6	1.1	.7	.1	.4	.1	.6	.5	1.1
3	1.9	1.7	1.5	4.0	1.0	.6	.1	.4	.1	1.0	.3	2.3
4	1.6	1.7	1.5	5.2	1.0	.8	.1	.5	.2	1.3	.2	2.3
5	1.4	1.6	1.5	5.5	1.3	.9	.....	.5	.2	.8	.1	1.8
6	1.1	3.5	1.4	4.5	1.4	.9	.....	.5	.2	.4	.1	1.2
7	1.1	7.1	1.5	3.8	1.3	.8	.....	.4	.2	.2	.1	.9
8	1.0	8.8	1.7	2.8	1.2	.7	.....	.3	.2	.1	.....	.8
9	1.0	10.2	1.6	2.2	1.0	.6	.....	.2	.3	.1	1.0	.7
10	.9	9.9	1.5	1.9	.9	.7	.....	.1	.3	.1	.7	.6
11	1.0	9.4	2.1	1.8	.8	1.0	.....	.1	.3	.1	.4	.5
12	1.1	8.6	2.6	1.7	.7	.8	4.2	.1	.3	.2	.4	.5
13	1.1	7.2	3.0	1.6	.6	.7	2.7	.1	.3	.2	.8	.4
14	.9	5.7	2.7	1.5	.6	.6	1.5	.1	.3	.2	1.0	.4
15	.9	5.0	2.4	1.4	.5	.6	1.0	.1	.3	.2	2.0	.6
16	.9	4.9	1.2	1.3	.4	.5	1.0	.1	.3	.2	3.3	.5
17	1.5	4.7	2.7	1.2	.4	.4	1.4	.1	.3	.2	3.0	.6
18	1.8	4.1	3.3	1.1	.4	.3	1.4	.1	.3	.2	2.3	.7
19	1.8	3.5	3.7	1.1	.4	.3	1.5	.1	.3	.2	1.3	.8
20	2.2	2.9	4.8	1.1	.3	.3	1.9	.1	.3	.2	.8	.6
21	1.9	2.5	5.2	1.0	.3	.3	1.6	.1	.3	.2	.6	.5
22	2.3	2.2	4.8	.9	.3	.3	1.3	.1	.1	.2	.4	.4
23	4.6	2.0	4.0	.9	.3	.5	1.0	.1	.2	.2	.4	.4
24	6.0	1.9	3.4	.9	.4	.6	.9	.0	.3	.2	.4	.3
25	6.7	1.8	3.0	.9	.4	.5	.9	.1	.3	.2	.3	.3
26	7.1	1.7	2.6	.9	.5	.2	.9	.1	.3	.2	.2	.3
27	6.7	1.5	2.4	1.1	.6	.2	.9	.1	.3	.2	.2	.2
28	5.5	1.6	2.2	1.3	.6	.2	.8	.1	.3	.2	.3	.2
29	4.3	1.6	2.0	1.1	.6	.2	.6	.1	.3	.1	.3	.2
30	3.1	.....	1.9	1.0	.5	.2	.5	.1	.3	.1	.4	.2
31	2.4	.....	1.8	.....	.6	.....	.4	.1	.....	.1	.....	.2

[1] Record from United States Engineer Office.

Black Warrior River[1] *at Tuscaloosa, Alabama, for 1889.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1....	15.00	23.50	18.80	8.50	8.80	2.80	2.40	3.70	0.75	2.40	0.90	6.00
2....	19.50	20.50	16.50	9.80	14.50	2.90	3.10	3.60	7.30	1.95	1.05	5.65
3....	18.00	17.50	25.00	10.30	13.20	2.75	4.40	3.00	6.40	1.55	1.85	5.30
4....	16.00	14.80	31.50	11.60	11.00	2.50	5.10	2.95	5.30	1.30	1.90	4.80
5....	25.00	13.00	29.40	10.50	8.50	2.30	6.25	2.90	6.20	1.15	3.85	4.50
6....	33.00	11.50	26.50	9.50	7.00	2.10	6.85	3.70	9.30	1.05	3.65	4.20
7....	33.50	10.40	23.00	8.40	5.80	1.90	6.45	3.45	14.90	.90	3.30	4.00
8....	29.50	9.30	20.10	7.30	4.60	1.70	5.70	2.95	19.00	.70	3.00	3.80
9....	26.80	8.30	17.50	6.80	4.30	2.00	4.75	2.60	14.00	.50	2.75	3.60
10....	28.40	8.00	15.00	6.40	4.00	2.60	3.85	2.00	9.90	.40	2.55	3.40
11....	29.00	7.80	12.80	6.30	3.80	2.85	3.05	1.75	5.50	.30	3.65	3.20
12....	25.50	7.60	11.00	6.00	3.20	4.20	2.85	1.55	5.25	.30	4.30	2.95
13....	22.50	7.30	10.00	5.60	3.00	3.40	2.45	3.85	4.15	.20	4.15	2.75
14....	19.00	7.00	9.20	5.50	3.10	4.00	2.15	3.60	3.30	.15	3.75	2.70
15....	16.00	7.30	8.80	8.00	3.20	3.45	1.95	3.35	2.70	.15	3.50	2.65
16....	13.60	27.50	8.10	16.80	3.00	3.25	4.20	3.15	2.25	.15	4.20	2.50
17....	29.00	49.00	7.20	16.70	2.80	3.05	7.35	3.80	2.00	.10	5.20	2.30
18....	40.50	56.40	7.10	14.00	2.50	2.85	11.35	3.50	1.55	.10	12.45	2.20
19....	38.50	56.60	11.00	12.00	2.35	2.65	11.50	3.20	1.40	.05	18.90	2.10
20....	34.00	53.00	12.50	10.00	2.25	2.45	8.40	2.90	1.30	.05	16.90	2.05
21....	30.30	47.00	12.30	8.90	2.05	2.25	4.60	2.40	1.20	.05	14.10	2.00
22....	28.10	41.50	11.80	8.00	1.85	3.25	4.55	1.90	1.10	.00	11.70	2.00
23....	26.00	36.50	10.80	7.00	1.65	3.45	4.50	1.50	1.00	— .10	9.70	2.00
24....	23.10	32.50	10.00	6.40	1.50	3.20	3.70	1.20	1.00	— .30	7.90	2.00
25....	21.00	28.50	9.80	6.30	1.30	3.00	3.15	.90	.95	— .15	6.60	1.95
26....	20.40	26.50	11.20	6.80	1.25	2.40	3.10	.75	2.25	+ .10	6.30	1.95
27....	28.00	23.50	11.80	6.50	1.15	1.95	4.55	1.00	3.70	.35	6.10	1.95
28....	33.50	21.40	12.30	6.20	1.05	1.55	4.05	.95	3.50	.35	5.90	1.90
29....	33.80	.....	11.00	5.80	.95	1.25	4.00	.90	3.25	.40	5.80	1.90
30....	30.00	.....	10.50	5.50	1.15	1.10	4.00	1.10	2.60	.90	6.30	3.00
31....	27.00	.....	9.80	.....	1.10	.....	3.80	1.05	.....	1.00	.....	4.85

Black Warrior River[1] *at Tuscaloosa, Alabama, for 1890.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	7.70	30.20	58.90	24.50	16.70	7.75	1.80	5.00	8.00	9.30	3.75	1.00
2.....	7.20	26.20	57.40	34.50	13.70	6.50	1.65	4.05	5.80	7.40	3.35	1.00
3.....	6.20	22.50	52.40	34.10	11.95	5.65	1.45	3.25	4.35	6.10	3.10	1.00
4.....	5.20	19.05	45.80	43.60	12.75	5.00	1.25	2.85	3.40	5.10	2.85	1.00
5.....	5.20	16.40	40.85	45.90	14.65	4.40	1.10	3.15	3.10	4.40	2.55	1.00
6.....	4.80	13.90	37.15	44.50	16.50	4.00	.80	3.35	3.85	3.80	2.40	1.00
7.....	4.50	12.10	35.40	38.70	15.00	5.20	.60	3.75	4.35	3.50	2.25	1.20
8.....	4.55	44.30	32.60	34.00	13.50	5.60	.50	4.55	4.80	3.45	2.15	10.05
9.....	5.10	53.95	30.50	29.95	11.95	5.40	.45	4.30	2.85	4.50	2.05	10.10
10.....	5.30	52.90	27.50	26.70	10.10	5.25	.30	4.30	3.20	4.45	2.00	8.95
11.....	5.60	47.50	25.00	23.45	9.30	5.00	.20	6.10	2.90	4.10	1.95	7.10
12.....	5.45	42.20	23.00	20.45	8.35	6.00	.15	6.40	3.45	3.80	1.75	5.80
13.....	5.30	37.20	20.75	17.45	8.35	6.20	.05	5.30	3.95	3.50	1.65	4.60
14.....	5.20	32.65	22.50	14.50	9.00	6.20	1.05	4.50	5.80	3.20	1.60	3.70
15.....	5.60	29.45	38.20	12.15	8.75	5.60	2.55	3.20	5.55	2.80	1.60	3.30
16.....	11.20	26.95	38.00	10.65	8.65	5.05	3.10	2.80	4.50	2.70	1.55	2.95
17.....	19.30	23.95	35.80	10.35	9.50	4.35	3.55	2.50	3.55	2.60	1.65	2.80
18.....	21.00	21.45	32.30	12.95	8.90	4.30	3.65	2.70	2.90	2.40	1.60	2.75
19.....	18.40	18.45	29.00	13.20	8.15	4.20	4.15	2.55	2.45	2.30	1.55	2.20
20.....	15.40	15.65	27.20	13.95	7.95	3.70	4.75	2.40	2.10	2.10	1.50	2.00
21.....	13.30	13.45	32.40	12.15	7.95	3.20	4.20	2.20	1.75	2.00	1.50	2.00
22.....	11.60	12.00	34.45	10.45	9.00	2.80	3.00	1.80	1.70	2.45	1.45	1.90
23.....	10.10	10.40	41.25	9.30	8.40	2.50	2.10	1.40	3.05	4.90	1.35	1.90
24.....	10.70	9.40	40.25	10.65	7.65	2.25	1.75	1.10	3.10	8.45	1.30	1.80
25.....	12.50	9.50	36.75	15.45	6.95	2.25	2.75	1.00	13.05	10.55	1.25	1.80
26.....	13.50	13.50	33.35	26.50	6.85	2.15	12.65	.95	23.90	9.60	1.20	2.30
27.....	12.80	35.20	29.70	28.45	9.60	2.55	13.40	.95	22.65	8.05	1.15	6.80
28.....	11.80	53.10	27.45	26.20	13.20	2.25	10.50	5.10	18.00	6.45	1.10	9.70
29.....	10.60	.....	24.55	23.35	13.55	2.05	9.30	9.55	14.70	5.30	1.05	10.20
30.....	17.60	.....	21.95	19.80	11.95	1.90	7.45	9.15	11.90	4.90	1.00	9.10
31.....	31.70	.....	18.80	.....	9.25	.....	6.50	10.45	.....	4.15	.....	7.30

[1] Record from United States Engineer Office.

Black Warrior River[1] *at Tuscaloosa, Alabama, for 1891.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1...	6.10	33.20	24.00	34.00	5.70	1.80	2.10	6.50	1.00	—0.40	—0.80	3.40
2...	8.60	39.60	23.50	39.40	5.50	1.90	2.00	13.00	1.00	— .30	— .80	3.00
3...	14.30	40.90	20.50	36.80	5.30	1.80	1.90	14.80	1.00	— .20	— .80	2.40
4...	17.90	40.20	19.60	32.50	4.90	1.70	1.80	16.00	.80	— .20	— .80	6.20
5...	15.20	39.30	17.20	28.50	4.50	1.50	1.50	13.00	.70	— .20	— .80	6.80
6...	13.10	36.30	29.00	25.00	4.50	1.40	1.30	9.50	.60	— .20	— .80	21.50
7...	11.10	37.00	53.00	22.20	4.20	1.40	1.40	7.40	.60	— .40	— .80	19.50
8...	10.00	51.50	58.00	19.00	4.00	1.50	2.10	5.80	.60	— .50	— .80	20.00
9...	9.50	51.50	60.40	16.00	3.90	2.10	7.00	5.40	.60	— .60	— .80	20.50
10...	17.50	52.20	58.00	14.20	3.50	2.80	10.40	3.70	.60	— .70	+ .70	17.00
11...	20.90	53.50	54.00	17.20	3.20	3.50	8.20	3.10	.70	— .80	2.10	14.00
12...	26.30	50.50	48.00	27.00	3.20	10.20	6.00	2.70	1.00	— .80	2.80	11.50
13...	30.10	47.60	43.00	26.00	3.10	10.50	4.30	2.50	1.20	— .80	4.40	9.00
14...	25.50	51.40	40.00	22.50	3.00	9.80	3.20	3.00	1.20	— .80	3.80	6.20
15...	21.00	49.50	36.50	19.50	2.80	8.00	2.30	3.40	1.00	— .60	2.50	7.00
16...	18.50	46.50	33.20	17.20	2.60	6.50	2.60	4.00	1.00	— .70	2.00	9.00
17...	17.10	44.30	30.00	15.60	2.50	5.60	2.60	3.00	.60	— .70	1.80	11.00
18...	17.70	41.00	28.00	16.40	2.50	6.30	2.90	2.60	.20	— .70	1.80	11.20
19...	17.10	37.50	26.40	14.50	2.50	7.20	2.50	2.20	.10	— .60	1.50	10.00
20...	15.60	35.00	24.00	13.40	2.50	7.00	2.20	2.00	.10	— .70	1.30	8.50
21...	12.60	33.50	21.00	12.00	2.50	6.00	1.80	1.50	.10	— .70	1.40	7.00
22...	20.20	39.50	19.90	11.00	2.70	5.50	1.60	1.50	.10	— .60	3.00	6.00
23...	31.60	41.00	17.50	10.00	3.00	5.20	1.40	1.40	.10	— .60	8.00	6.00
24...	31.80	39.00	15.00	9.00	3.00	4.80	1.30	1.30	.10	— .50	12.30	6.20
25...	30.10	36.50	12.50	8.20	2.80	4.50	1.40	1.20	.00	— .50	13.30	7.50
26...	30.70	33.00	12.10	7.60	2.60	4.20	2.60	1.10	.00	— .50	10.80	13.20
27...	29.00	29.00	15.00	8.40	2.50	4.10	2.00	1.10	— .20	— .70	7.20	31.00
28...	26.80	26.50	18.20	8.00	2.40	3.70	2.20	1.00	— .20	— .80	5.80	38.90
29...	23.70	.....	19.40	7.30	2.30	2.90	2.00	1.00	— .40	— .80	4.20	31.20
30...	32.70	.....	18.00	6.50	2.10	2.50	2.10	1.10	— .50	— .80	3.80	27.00
31...	33.00	.....	17.00	.....	2.00	.....	2.40	1.00	.....	— .80	.....	22.10

Black Warrior River[1] *at Tuscaloosa, Alabama, for 1892.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	17.90	12.20	10.70	21.80	12.00	3.40	4.60	4.80	9.30	3.90	0.40	5.90
2.....	15.90	10.50	10.30	18.30	11.20	3.20	3.90	3.20	7.60	3.50	.40	5.60
3.....	18.50	9.40	9.70	15.50	9.90	3.50	3.40	7.00	6.50	3.30	1.20	5.30
4.....	18.70	8.50	8.80	15.20	8.80	3.70	3.00	7.40	5.60	3.10	1.60	4.90
5.....	16.40	7.80	8.00	12.00	7.20	3.50	2.90	6.60	4.90	2.80	1.60	6.30
6.....	14.60	7.40	7.80	11.60	6.50	4.70	3.50	5.40	4.90	2.50	1.60	7.50
7.....	13.00	7.80	8.00	56.30	5.90	5.00	5.20	4.80	4.80	2.40	2.00	7.50
8	11.60	7.50	16.50	63.20	5.30	4.90	11.00	3.90	6.40	2.20	3.90	12.20
9.....	10.80	9.00	26.80	62.20	5.20	4.10	26.70	3.60	6.20	2.10	4.60	15.00
10.....	10.50	16.00	28.50	58.00	4.90	4.00	43.50	3.50	5.40	2.00	8.90	13.20
11.....	25.70	13.00	26.70	52.30	4.90	3.80	46.20	3.00	5.10	2.00	10.90	11.00
12.....	34.80	11.30	22.00	45.40	4.80	3.50	41.40	3.00	3.90	2.00	8.30	9.40
13.....	53.00	10.80	18.00	40.70	4.70	3.30	38.30	3.30	3.40	2.00	7.60	8.00
14.....	57.40	9.50	15.80	36.50	4.60	2.80	37.50	3.10	3.30	1.90	5.80	7.40
15.....	55.90	9.00	13.80	32.80	4.50	2.50	34.80	3.90	4.00	1.90	5.00	8.60
16.....	51.70	10.00	13.30	29.50	4.00	2.40	32.80	3.50	5.10	1.90	4.50	10.30
17.....	45.00	11.80	11.20	27.00	3.70	2.00	41.40	3.50	4.90	1.80	4.00	13.10
18.....	40.10	11.00	12.90	24.50	3.60	1.80	38.00	6.00	4.30	1.70	4.20	26.70
19.....	36.60	9.90	24.00	22.40	4.30	1.10	33.00	9.50	6.00	1.00	4.40	28.40
20.....	41.50	10.50	25.50	20.20	4.60	2.90	29.00	11.50	18.30	1.00	4.70	28.40
21.....	41.00	13.50	22.90	18.10	6.50	3.40	28.30	9.50	23.90	.90	5.00	36.50
22.....	36.80	18.00	20.00	15.90	6.30	7.80	29.30	7.40	20.90	.90	4.80	35.80
23.....	34.40	23.90	18.30	13.80	6.00	10.70	25.10	10.20	17.00	.90	4.50	31.50
24.....	31.00	21.20	22.00	12.30	6.00	10.40	21.50	12.30	13.30	1.00	4.20	27.00
25.....	28.50	18.50	29.00	11.30	4.80	8.80	18.80	14.00	10.50	1.00	3.80	23.00
26.....	26.00	16.00	32.00	10.50	3.50	7.90	15.80	14.20	8.00	.90	3.50	19.50
27.....	23.80	14.00	35.80	8.80	4.70	7.20	13.00	13.20	6.10	.80	3.30	16.00
28.....	21.50	12.50	34.00	7.90	4.00	7.10	10.50	11.50	5.00	.70	3.20	13.60
29.....	19.00	11.50	30.50	7.70	3.80	6.20	7.80	12.00	4.90	.70	3.90	11.40
30.....	16.80	.....	26.80	10.50	3.50	5.40	6.20	11.50	4.30	.50	5.90	9.80
31.....	14.00	.....	23.90	.....	3.50	.....	5.50	10.50	.....	.50	.....	8.50

[1] Record from United States Engineer Office.

Black Warrior River[1] *at Tuscaloosa, Alabama, for 1893.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	8.20	18.10	23.00	9.40	24.50	12.50	2.50	0.60	0.30	1.10	0.40	1.50
2	8.60	15.90	21.70	9.30	21.20	33.50	2.30	.70	.20	1.00	.40	1.50
3	9.80	14.00	19.70	9.00	30.00	49.60	2.80	1.00	.10	1.20	.40	1.80
4	10.70	12.80	20.50	8.70	51.20	46.00	3.60	1.20	.00	1.40	.40	2.80
5	10.10	12.50	23.00	8.00	52.20	39.00	3.60	1.30	—.10	1.30	.40	3.50
6	9.00	11.80	24.00	8.70	48.00	37.70	3.20	1.20	—.10	1.20	.40	4.20
7	8.40	11.20	22.60	9.30	42.90	39.90	2.70	1.30	.00	1.20	.40	4.10
8	7.90	10.80	20.10	9.00	40.40	39.30	2.40	1.20	+.20	1.20	.40	3.50
9	7.00	10.60	20.00	8.30	37.40	34.00	2.10	1.00	1.40	1.00	.40	3.00
10	6.70	10.20	22.00	7.60	34.30	29.20	1.80	.90	2.00	.90	.60	2.80
11	6.20	12.00	21.80	7.00	30.80	25.10	1.60	.90	2.10	.80	.60	2.30
12	6.50	23.90	20.50	6.40	27.50	21.20	1.60	.80	2.20	.80	.50	1.90
13	7.80	28.30	19.30	6.10	24.40	17.40	2.20	.90	3.20	.80	.50	1.70
14	9.00	27.00	18.10	5.80	21.90	14.70	2.60	3.60	4.30	.70	.60	1.60
15	9.60	25.90	16.30	23.00	19.10	11.60	2.40	4.90	4.30	.70	.60	1.50
16	11.40	52.20	14.70	27.10	16.20	9.60	2.00	5.10	3.90	.60	.60	1.70
17	12.20	55.60	13.20	24.00	14.00	7.60	1.70	4.70	3.30	.50	.60	2.30
18	11.80	54.70	12.20	20.00	11.90	6.70	1.40	3.70	2.50	.50	.60	2.40
19	12.00	51.40	11.30	16.40	11.00	6.50	1.30	2.80	2.10	.50	.60	2.30
20	12.40	46.50	10.70	13.90	8.40	6.90	1.20	2.20	1.80	.50	.60	2.10
21	11.80	41.80	9.90	12.00	6.90	6.90	1.20	1.70	1.40	.50	.70	2.50
22	10.90	37.90	9.30	11.20	6.20	6.60	1.30	1.50	1.30	.50	1.00	2.40
23	11.20	34.50	8.80	10.70	5.60	6.40	1.60	1.30	1.20	.40	1.00	2.30
24	12.90	31.30	13.30	9.90	5.10	5.70	1.70	1.10	1.00	.40	1.10	2.10
25	15.90	28.40	22.20	8.90	4.80	4.90	1.50	1.00	1.30	.40	1.00	1.90
26	19.20	25.90	22.50	7.00	4.50	4.40	1.30	.90	1.20	.40	.90	1.70
27	22.00	23.80	20.00	10.50	4.30	4.00	1.20	.80	1.20	.40	1.00	1.60
28	23.30	23.00	17.00	32.50	5.10	3.50	.90	.80	1.10	.40	1.70	1.50
29	23.10	.....	14.40	33.90	6.10	3.10	.90	.60	1.10	.40	1.70	1.40
30	22.10	.....	12.40	29.00	12.90	2.80	.80	.50	1.10	.40	1.50	3.70
31	20.40	.....	10.90	.....	14.10	.....	.80	.20	.....	.40	.....	7.60

Black Warrior River[1] *at Tuscaloosa, Alabama, for 1894.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	10.30	8.50	27.00	11.40	6.50	1.70	2.50	1.20	5.80	0.55	—0.05	—0.05
2	9.60	7.80	25.60	14.10	5.90	1.60	1.80	1.30	4.60	.45	—.10	—.05
3	7.90	7.30	23.60	23.50	5.90	1.50	1.35	1.40	3.60	.40	—.20	.00
4	6.20	7.00	21.00	24.00	5.80	1.35	1.10	1.95	2.95	.32	—.25	.00
5	5.40	16.90	18.20	22.20	5.50	1.33	.80	2.30	2.45	.25	—.30	.00
6	6.40	22.60	15.90	20.60	5.20	1.20	.60	2.40	2.05	.20	—.30	.00
7	16.80	20.40	14.80	18.90	5.10	1.20	1.00	2.00	1.85	.15	—.30	.00
8	22.60	17.80	14.40	16.30	4.90	1.10	1.30	1.60	1.75	.00	—.30	+.05
9	19.70	17.30	13.80	14.70	4.50	.95	.70	1.30	1.65	—.10	—.30	.05
10	26.90	26.00	12.60	15.70	4.10	.90	.70	1.10	1.60	—.20	—.30	.50
11	34.50	27.80	11.60	25.00	3.70	.80	.60	.80	1.85	—.25	—.30	2.10
12	35.80	25.40	11.50	25.60	3.90	.80	.60	.70	3.40	—.30	—.30	5.70
13	30.90	29.90	16.50	22.70	4.30	.70	.50	.60	5.60	—.30	—.30	10.40
14	25.80	32.10	17.30	19.50	7.00	.60	.50	.50	7.50	—.30	—.15	11.20
15	22.20	29.70	15.80	16.30	6.20	.60	.60	.35	5.70	—.30	.00	8.90
16	23.60	26.00	15.50	15.50	5.70	.60	.70	.60	4.20	—.30	+.05	6.40
17	24.80	22.30	33.10	16.00	5.10	.55	.75	.55	3.25	—.30	.05	4.90
18	22.40	19.10	36.70	17.00	5.00	.50	.70	.45	3.50	—.30	.05	3.90
19	19.30	16.80	33.70	25.30	4.70	.60	.70	.40	3.25	—.30	.00	3.20
20	15.90	16.00	29.50	24.80	4.20	.70	.60	.55	3.35	—.30	—.10	2.90
21	14.10	16.90	27.80	24.00	3.60	.85	.50	1.00	4.10	—.30	—.10	2.60
22	18.60	17.90	29.30	20.40	3.10	.80	.90	1.35	3.60	—.30	—.10	2.20
23	21.30	17.00	29.60	17.30	2.80	.95	1.30	3.80	2.90	—.30	—.10	2.00
24	19.90	16.10	28.00	14.20	2.60	1.10	1.35	5.30	2.20	—.35	.00	1.80
25	17.60	17.30	27.80	12.20	2.40	1.00	1.60	9.20	1.75	—.40	.00	1.70
26	15.50	29.30	25.30	10.50	2.30	1.05	1.50	16.00	1.45	—.40	.00	2.00
27	14.00	31.00	22.10	9.80	2.10	1.40	1.40	20.40	1.20	—.45	—.05	7.70
28	12.40	28.80	19.00	8.70	2.10	1.70	1.30	16.00	1.05	—.45	—.05	9.70
29	11.10	.....	16.10	7.90	2.00	2.35	.20	11.80	.90	—.45	—.05	8.40
30	10.00	.....	14.30	7.00	1.90	2.60	1.10	8.30	.70	—.20	—.05	7.20
31	9.10	.....	12.70	.....	1.90	.....	1.20	6.80	.....	—.05	—.05	6.50

[1] Record from United States Engineer Office.

Black Warrior River[1] *at Tuscaloosa, Alabama, for 1895.*

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.10	24.10	8.60	16.20	15.20	7.00	4.80	1.80	1.90	0.10	—0.04	0.75
2	5.40	21.50	13.20	14.50	13.00	5.90	4.50	1.50	1.80	.00	+ .07	.95
3	6.80	21.40	35.30	12.60	11.00	5.10	5.40	1.30	1.80	— .07	.12	1.05
4	9.00	21.40	36.70	11.00	9.40	4.60	7.60	1.20	1.70	— .10	.09	1.00
5	8.80	19.90	32.40	10.20	8.30	4.20	17.40	1.20	1.90	— .10	.11	.90
6	8.00	17.90	27.80	8.40	7.40	6.70	17.70	1.20	2.60	— .10	.25	1.30
7	7.40	16.50	23.80	7.90	7.00	5.70	18.40	1.10	3.05	— .10	.31	1.50
8	35.00	16.80	20.60	20.50	8.20	5.10	15.70	1.00	3.70	.00	.30	1.45
9	50.60	16.90	20.10	24.00	13.50	4.30	13.10	.90	3.40	— .03	.28	1.90
10	49.30	15.80	19.30	21.20	19.70	3.80	11.10	.97	2.90	— .07	.70	1.80
11	45.10	14.60	17.50	18.00	23.30	3.10	9.80	1.40	2.40	— .10	1.20	1.45
12	40.10	14.10	17.20	15.10	22.00	2.70	7.90	1.50	2.20	— .14	1.10	1.40
13	35.00	13.90	18.40	12.60	18.50	2.40	6.50	1.40	2.10	— .14	1.18	1.40
14	29.80	12.80	24.90	11.00	15.20	2.20	5.30	1.30	2.00	+ .06	1.35	1.37
15	25.70	11.60	37.50	9.50	12.20	2.00	5.40	1.10	1.80	.04	1.35	1.33
16	23.40	10.50	47.40	8.60	9.70	2.00	5.60	1.30	1.60	— .08	1.28	1.23
17	31.20	9.40	52.00	10.00	8.00	2.70	5.90	1.40	1.40	— .18	1.20	1.12
18	32.90	9.00	47.30	15.90	6.90	3.30	5.80	2.00	1.40	— .27	1.05	1.05
19	29.20	9.00	42.10	15.80	6.30	4.20	5.10	4.00	1.30	— .31	.88	1.02
20	25.80	9.50	38.80	14.00	5.90	4.90	4.60	4.30	1.00	— .37	.82	1.57
21	23.10	10.20	48.70	12.00	5.30	4.70	4.00	3.60	1.20	— .42	.70	2.55
22	21.60	10.90	51.30	10.40	4.80	4.30	3.60	2.80	1.50	— .45	.60	2.60
23	21.60	11.40	47.60	8.90	4.30	4.10	3.40	2.40	1.30	— .50	.50	3.03
24	19.80	11.30	42.10	8.00	4.10	3.70	3.30	4.30	1.10	— .35	.75	3.65
25	17.40	10.90	37.30	7.20	4.00	3.40	3.60	4.90	.80	— .33	.60	3.31
26	16.70	10.30	32.80	7.00	4.30	3.00	3.70	4.00	.60	— .53	.38	4.50
27	20.00	9.70	29.10	7.10	5.60	4.40	3.30	3.20	.35	— .70	.64	10.40
28	21.20	9.00	26.10	12.50	11.00	5.40	2.90	2.40	.10	— .68	.65	21.02
29	22.00	.....	23.60	15.00	13.30	6.00	2.40	2.30	.50	— .67	.65	16.88
30	27.40	.....	21.10	16.40	11.20	5.40	2.00	2.10	.30	— .50	.60	13.10
31	27.10	.....	18.60	.....	8.90	.....	2.10	2.00	.....	— .32	.....	11.67

Black Warrior River[1] *at Tuscaloosa, Alabama, for 1896.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	11.41	7.92	6.91	10.61	18.24	4.92	1.94	.53	0.38	—0.52	—0.78	7.70
2	10.26	8.51	7.66	14.78	33.30	4.28	1.71	.80	.25	— .62	— .77	6.32
3	8.90	21.98	7.41	23.00	37.18	3.50	1.44	1.34	.15	— .06	— .42	4.63
4	7.60	33.12	6.74	23.50	30.88	5.44	1.48	.89	.05	— .20	— .39	3.40
5	6.55	30.02	6.14	19.85	26.40	5.24	1.30	.54	— .00	+ .78	— .33	2.60
6	5.74	30.75	6.64	16.70	21.93	4.30	1.15	.42	— .15	.74	— .19	2.05
7	5.09	35.92	10.18	14.26	17.88	3.62	1.32	.50	— .23	.68	— .19	1.70
8	5.24	35.08	12.04	12.55	13.95	3.27	2.20	.60	— .30	.40	— .17	1.47
9	5.76	36.21	14.89	11.20	10.80	6.60	8.40	.68	— .37	.09	— .18	1.21
10	6.46	36.52	13.69	10.02	8.60	8.18	6.98	.64	— .44	— .15	— .21	1.10
11	6.58	33.65	12.45	9.04	7.11	18.39	5.37	.55	— .44	— .28	— .30	.89
12	6.25	29.45	13.97	8.33	6.09	15.13	3.95	.45	— .46	— .28	— .20	.84
13	5.79	25.97	16.15	7.62	5.34	10.77	2.99	.38	— .50	— .48	— .22	.80
14	5.26	27.41	15.35	7.86	4.77	7.66	2.45	.35	— .60	— .49	— .11	.75
15	4.82	33.25	13.56	11.65	6.13	5.60	2.16	.31	— .59	— .46	— .10	1.20
16	4.87	31.02	13.86	13.90	5.45	4.33	2.13	.26	— .59	— .43	— .01	1.25
17	6.03	27.30	22.30	12.36	4.65	4.74	2.15	.13	— .60	— .60	+ .26	1.25
18	8.61	23.65	27.75	10.57	3.94	4.20	2.42	.40	— .60	— .63	.46	1.60
19	9.14	20.09	29.70	9.03	3.44	6.18	2.46	.50	— .60	— .78	.52	1.90
20	8.53	17.00	37.68	7.81	3.05	6.00	2.24	.40	— .61	— .82	.45	1.70
21	7.87	14.45	37.92	6.88	2.91	5.32	2.16	.34	— .64	— .82	.39	1.50
22	8.85	12.20	33.55	6.15	2.77	4.91	1.90	.29	— .64	— .84	.38	1.33
23	22.48	10.32	29.12	5.56	2.87	4.46	1.71	.22	— .36	— .84	.38	1.20
24	29.26	9.13	25.85	5.67	2.90	4.19	2.06	1.06	— .45	— .78	.37	.98
25	26.52	8.60	23.54	5.76	2.87	4.04	2.53	.95	— .61	— .80	.37	.92
26	22.44	8.35	21.28	5.30	2.97	3.37	2.17	.79	— .64	— .82	.37	.77
27	18.55	7.90	18.72	5.20	3.66	2.85	1.70	.77	— .71	— .82	.08	.71
28	14.92	7.40	16.35	10.47	3.59	2.09	1.28	1.35	— .76	— .78	.09	.59
29	12.14	7.00	14.30	16.06	6.52	2.54	.94	1.30	— .67	— .80	.33	.52
30	10.18	.....	12.69	14.18	6.50	2.21	.76	.95	— .55	— .80	1.00	.48
31	8.88	.....	11.40	.....	5.78	.....	.64	.60	.....	— .78	.....	.48

[1] Record from United States Engineer Office.

Greenbrier River at Alderson, West Virginia.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.45	2.25	2.50	7.00	3.05	2.07	2.47	4.50	1.63	6.60	1.67	4.75
2	3.08	2.27	2.82	6.60	3.35	1.97	2.25	3.75	1.60	4.02	1.73	3.85
3	2.65	4.95	2.70	5.50	3.05	1.90	2.20	4.35	1.55	3.20	1.70	3.40
4	2.25	6.30	2.50	4.40	4.15	1.88	2.10	3.55	1.60	2.80	1.80	3.05
5	2.45	4.55	2.35	3.85	4.60	1.85	2.35	3.05	1.55	2.55	7.67	2.80
6	2.40	3.55	2.33	3.20	3.70	2.00	2.30	2.72	1.60	2.38	9.50	2.65
7	1.90	4.80	2.30	3.10	3.23	2.05	2.55	2.50	1.60	2.20	4.85	2.60
8	1.98	4.20	2.40	2.95	2.95	2.20	a3.08	2.35	1.60	2.10	3.60	2.50
9	1.95	3.60	2.60	3.00	2.85	2.20	6.95	2.25	1.63	2.00	3.15	2.45
10	2.10	3.40	2.70	3.05	2.65	2.20	6.40	2.10	1.64	1.95	2.85	2.65
11	2.05	3.15	2.60	3.10	2.45	2.70	4.28	2.10	1.60	1.90	2.60	3.10
12	2.05	2.85	2.90	3.15	2.35	2.48	3.47	2.10	1.57	1.85	2.48	2.93
13	2.05	2.20	3.00	3.05	2.25	2.20	3.03	2.00	1.55	2.20	2.40	2.78
14	2.30	5.80	2.75	3.00	2.25	2.10	2.85	1.90	1.53	2.15	2.30	2.62
15	2.20	5.50	2.85	2.98	2.65	2.00	2.58	1.95	1.55	2.13	2.25	2.60
16	1.70	4.15	2.95	2.95	2.55	2.05	2.48	2.10	1.95	2.10	2.15	3.00
17	1.70	3.60	6.75	2.75	2.30	2.08	2.42	2.00	1.75	2.00	2.10	3.00
18	1.72	3.05	5.60	2.60	2.10	2.10	2.40	1.85	1.63	1.95	2.05	2.85
19	1.73	2.85	4.50	2.55	2.05	2.05	2.35	1.85	1.57	1.90	2.03	2.65
20	1.73	2.60	6.40	2.50	2.05	2.08	2.28	1.80	1.75	1.85	2.00	2.55
21	1.82	2.38	5.20	2.40	2.30	2.05	2.15	1.75	1.70	1.78	2.00	2.43
22	1.85	2.42	4.50	2.35	2.40	1.97	2.10	1.65	1.70	1.75	2.09	2.35
23	1.90	2.38	4.35	2.35	2.50	1.95	2.07	1.73	1.64	1.73	2.20	2.25
24	2.65	2.25	4.15	2.40	2.50	1.90	2.58	1.93	1.69	1.70	2.22	2.20
25	4.20	2.45	4.15	3.10	2.60	1.95	2.64	1.95	1.60	1.70	2.20	1.90
26	3.93	2.33	3.85	3.05	2.65	8.20	5.38	1.96	1.53	1.73	2.18	1.70
27	3.23	2.28	3.80	3.00	2.55	3.75	3.85	1.93	1.53	1.70	2.15	1.50
28	2.85	2.22	3.70	2.80	2.45	3.20	3.10	1.87	1.55	1.80	2.15	1.40
29	2.60	2.28	3.15	2.68	2.42	3.10	2.80	1.70	1.62	1.73	2.45	1.80
30	2.38	.....	a10.50	2.65	2.28	2.80	2.55	1.70	4.93	1.70	5.55	1.95
31	2.30	.....	8.88	.....	2.17	.....	3.83	1.67	.....	1.70	.....	2.05

a Heavy rain.

New River at Fayette, West Virginia.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.10	3.70	3.75	22.25	6.20	2.85	6.08	4.60	1.10	14.90	1.25	12.80
2	3.60	4.90	3.30	23.60	6.60	2.60	5.00	5.10	1.00	9.45	1.00	11.50
3	4.80	12.50	2.95	21.15	6.70	2.75	4.10	4.85	.90	6.00	1.30	8.08
4	3.70	11.80	2.50	17.60	7.05	2.95	2.80	4.50	.80	4.50	2.15	7.40
5	3.10	9.65	2.20	15.40	7.30	3.55	3.00	4.25	.80	3.45	6.98	5.80
6	2.19	7.80	2.90	11.10	7.00	3.58	3.15	4.00	1.00	3.10	17.10	5.32
7	1.75	7.65	3.40	10.30	6.15	3.35	3.45	3.65	1.20	2.65	13.25	4.95
8	1.40	11.55	3.70	9.00	5.20	3.55	3.90	3.90	2.50	2.05	6.53	4.40
9	1.20	11.40	4.50	8.20	4.70	3.75	17.30	3.80	2.30	1.40	7.65	.....
10	1.90	8.65	4.00	7.10	4.55	4.00	25.20	3.60	2.00	1.90	6.30	.....
11	3.00	5.35	3.35	6.20	4.30	3.35	14.50	3.20	1.50	1.65	4.85	.....
12	2.75	4.15	3.70	6.05	4.05	3.00	14.00	2.95	1.25	1.70	3.00	.....
13	2.90	4.30	4.15	5.80	3.65	3.60	13.05	2.70	1.20	2.10	3.20	.....
14	2.40	7.90	5.00	5.50	3.30	3.00	12.00	2.10	1.15	2.80	3.50	.....
15	2.60	10.70	6.00	5.20	3.30	2.70	8.60	2.45	.90	3.30	3.60	.....
16	2.30	9.00	11.00	5.05	3.40	2.50	7.15	2.40	1.40	3.00	3.55	.....
17	2.10	7.50	14.93	4.85	3.20	2.40	6.05	2.30	1.30	2.80	3.25	.....
18	1.95	5.00	15.75	4.70	3.05	2.60	5.00	2.05	1.23	1.95	2.90	.....
19	2.00	4.70	15.05	4.45	3.15	3.00	4.10	1.85	1.00	1.10	2.45	6.30
20	2.30	4.20	13.00	4.20	3.25	3.20	4.40	1.40	.90	.85	2.45	5.60
21	2.50	2.90	11.50	4.30	3.50	3.40	5.40	1.25	.90	.50	2.60	5.00
22	2.10	2.35	11.00	4.50	3.75	3.75	5.70	1.35	.90	.40	2.90	4.65
23	2.40	3.30	10.15	4.70	3.60	4.00	4.95	1.85	.80	.50	3.00	4.05
24	2.60	4.05	9.40	4.90	5.90	4.45	4.10	1.50	1.05	1.45	2.95	3.70
25	6.00	4.60	8.85	5.10	5.45	5.15	4.45	2.10	1.10	1.30	2.70	3.00
26	10.00	4.80	8.15	5.00	5.00	6.30	4.47	2.35	1.10	1.20	2.72	.....
27	8.10	4.30	7.50	5.30	4.10	8.90	4.20	2.70	1.10	1.00	2.70	2.60
28	7.55	4.00	6.60	5.45	4.00	7.90	4.30	2.40	1.10	.70	3.10	2.75
29	6.70	3.90	7.40	5.80	3.55	7.53	4.50	2.15	.70	1.40	7.45	2.90
30	4.90	.....	18.40	6.00	3.20	6.80	4.45	1.75	.80	.60	8.30	2.50
31	4.00	.....	23.40	.....	3.23	.....	4.85	1.30	.....	1.30	.....	2.70

No observations December 9 to 17; wire gage broken.

French Broad River at Asheville, North Carolina.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.80	3.40	.....	3.80	2.80	2.90	2.56	3.20	2.50	2.65	2.75	5.80
2	3.40	3.40	.....	4.20	3.20	2.90	2.55	3.10	2.63	2.63	2.65	4.50
3	3.30	4.00	.....	3.70	4.60	2.90	2.65	3.25	2.70	2.60	2.65	4.10
4	3.20	3.70	.....	3.45	4.10	3.13	2.85	3.10	2.73	2.50	2.85	3.80
5	3.20	3.60	.....	3.30	3.90	2.90	2.86	2.90	2.95	2.45	6.10	3.80
6	3.30	4.05	.....	3.27	3.70	2.90	4.10	2.85	3.20	2.43	5.50	3.60
7	3.15	4.60	.....	3.25	3.50	2.73	5.10	2.85	3.10	2.40	5.43	3.50
8	3.10	4.43	.....	3.20	3.26	2.70	9.85	2.90	2.90	2.40	3.45	3.40
9	3.00	5.45	.....	3.15	3.20	3.15	8.73	2.85	2.65	2.40	3.35	3.40
10	2.75	4.70	.....	3.15	3.07	2.90	7.00	3.00	2.53	2.40	3.25	3.30
11	2.90	4.20	.....	3.02	3.05	2.75	6.10	3.00	2.55	2.40	2.75	3.25
12	2.90	3.95	.....	3.50	3.05	2.70	5.00	2.95	2.85	2.45	3.50	3.25
13	2.85	4.85	.....	3.25	3.03	2.67	4.80	2.80	2.55	2.50	4.25	3.20
14	2.85	4.45	.....	3.25	3.05	2.65	4.50	2.85	2.55	2.65	4.23	3.20
15	2.75	3.95	.....	3.15	2.87	2.60	4.30	2.95	2.57	2.55	4.20	3.25
16	2.80	3.80	3.50	3.10	2.80	2.60	4.25	3.25	2.57	2.45	3.85	3.30
17	2.80	3.70	3.40	2.95	2.76	3.15	4.15	2.95	2.65	2.43	3.75	3.30
18	3.40	3.60	3.40	2.90	2.76	3.30	4.03	2.80	2.53	2.40	3.63	3.25
19	3.20	3.50	3.16	2.93	2.70	3.39	3.80	2.78	2.50	2.43	3.50	3.10
20	3.15	3.40	3.70	2.93	2.70	3.18	3.75	2.80	2.40	2.46	2.95	3.10
21	3.15	3.40	3.30	2.93	2.70	2.95	3.70	2.80	2.40	2.45	2.93	3.05
22	3.10	3.30	3.20	2.95	2.90	3.00	3.65	2.65	2.37	2.42	2.90	3.05
23	5.30	3.35	3.20	2.95	3.05	3.14	3.63	2.75	2.50	2.45	2.70	3.14
24	6.50	3.35	3.30	2.95	3.10	3.15	3.60	2.70	2.50	2.45	2.85	3.00
25	5.80	3.30	3.20	2.92	3.00	3.15	3.55	2.70	2.45	2.45	2.80	2.95
26	4.40	3.35	3.15	2.86	2.70	2.93	3.35	2.70	2.45	2.45	2.90	2.90
27	3.95	3.25	3.10	2.82	3.05	2.80	3.40	2.60	2.35	2.45	3.10	2.90
28	3.75	3.35	3.10	2.82	2.75	3.05	3.50	2.60	3.00	2.47	4.05	2.87
29	3.60	3.30	3.50	2.82	2.75	2.75	3.40	2.50	2.70	2.50	4.95	2.85
30	3.40	.....	3.25	2.80	2.73	2.63	3.35	2.50	2.67	2.50	6.20	2.83
31	3.40	.....	3.30	.....	2.70	.....	3.25	2.50	.....	2.45	.....	2.83

Tuckaseegee River, three miles above Bryson, North Carolina.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.19	2.70	1.86	2.10	2.00	4.30	17	3.70	2.40	2.10	1.70	2.40	2.50
2	2.31	2.60	1.86	1.90	1.85	3.60	18	3.70	2.20	2.05	1.70	2.30	2.65
3	2.25	2.56	2.00	1.85	1.80	3.30	19	3.20	2.10	2.10	1.70	2.25	2.50
4	2.30	2.50	1.90	1.80	2.60	3.10	20	3.30	2.10	2.10	1.70	2.20	2.20
5	2.53	2.15	2.10	1.77	4.45	3.00	21	5.00	2.15	1.85	1.70	2.20	2.40
6	4.90	2.50	2.50	1.75	2.80	2.90	22	6.00	2.10	2.80	1.70	2.15	2.30
7	4.20	2.70	2.10	1.72	2.40	2.80	23	3.97	2.10	2.20	1.70	2.10	2.40
8	8.05	2.56	2.05	1.70	2.30	2.70	24	3.80	2.20	2.00	2.00	2.05	2.20
9	6.90	2.50	2.00	1.70	2.20	3.00	25	3.70	2.20	1.85	1.80	2.00	2.10
10	4.50	2.50	1.95	1.70	2.10	2.70	26	3.40	2.70	1.80	1.76	2.00	2.05
11	4.00	2.50	2.10	1.70	2.00	2.65	27	3.30	2.10	1.80	1.70	3.30	2.30
12	4.30	2.40	2.00	2.00	5.00	2.60	28	3.20	2.05	1.80	1.70	3.10	2.20
13	3.90	2.25	1.98	1.90	3.30	2.55	29	3.03	2.00	1.80	1.80	5.10	2.30
14	3.60	2.30	1.90	1.90	2.60	2.50	30	2.90	1.90	2.30	2.00	6.50	2.35
15	3.40	2.25	2.10	1.85	2.40	2.80	31	2.80	1.88	.....	2.70	.....	2.30
16	4.10	2.60	2.10	1.70	2.60	2.70							

Little Tennessee River at Judson, North Carolina.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.70	3.35	2.60	2.90	3.10	7.70	17	4.00	3.60	2.70	.....	3.70	4.53
2	2.80	3.30	2.60	2.80	2.90	6.30	18	3.65	3.10	2.70	.....	3.68	3.83
3	2.77	3.30	2.70	2.78	2.80	5.30	19	3.64	3.00	2.60	.....	3.60	3.88
4	2.95	3.30	2.80	2.68	2.99	4.30	20	3.70	3.00	2.70	.....	3.50	3.80
5	2.85	3.21	2.90	2.60	5.70	4.40	21	3.70	3.20	2.70	.....	3.50	3.80
6	3.82	3.19	2.90	2.53	4.55	4.30	22	4.10	3.85	2.67	.....	3.50	3.79
7	4.22	3.15	2.80	2.55	3.30	4.20	23	5.11	2.83	2.18	.....	3.50	3.78
8	6.70	3.13	2.60	2.54	3.30	4.10	24	4.28	2.92	2.68	.....	3.50	3.78
9	8.80	3.19	2.55	2.53	3.51	4.10	25	4.20	3.00	2.60	3.10	3.40	3.75
10	5.70	3.21	2.53	2.53	3.50	4.90	26	4.10	3.00	2.54	2.90	3.50	3.45
11	8.95	3.12	2.50	.....	3.40	4.80	27	3.85	2.80	2.60	2.90	3.60	3.46
12	4.65	3.10	2.64	.....	4.30	3.88	28	3.92	2.80	2.60	2.80	3.70	3.54
13	4.50	3.20	2.63	.....	5.70	3.89	29	3.80	2.90	2.60	2.90	6.10	3.46
14	4.20	3.10	2.53	.....	4.30	3.89	30	3.56	2.80	3.30	3.10	7.70	3.61
15	3.95	3.90	2.84	.....	4.20	4.30	31	3.45	(a)	.....	3.00	.....	3.60
16	4.00	3.70	2.75	.....	3.30	4.60							

a Rope broken.

Hiwassee River at Murphy, North Carolina.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.72	4.02	3.65	3.74	3.66	5.20	17	4.48	3.78	3.60	3.65	4.50	4.05
2	3.70	4.02	3.61	3.68	3.70	4.70	18	4.54	3.74	3.60	3.56	3.95	4.00
3	3.75	4.11	3.62	3.65	3.72	4.52	19	4.35	3.70	3.58	3.50	3.91	4.00
4	4.00	3.95	3.61	3.60	4.90	4.52	20	4.28	3.68	3.56	3.60	3.90	4.00
5	3.90	3.90	3.61	3.62	4.10	4.20	21	4.32	3.70	3.56	3.60	3.90	4.00
6	4.62	3.90	3.90	3.55	3.90	4.20	22	4.60	3.70	3.62	3.56	3.85	4.00
7	4.98	3.95	3.66	3.60	3.90	4.15	23	5.10	3.65	3.85	3.60	3.80	3.95
8	6.72	3.90	3.62	3.51	3.90	4.10	24	4.61	3.90	3.60	3.90	3.80	3.95
9	6.95	3.86	3.60	3.60	3.82	4.30	25	4.40	3.80	3.60	3.70	3.80	3.95
10	5.24	4.00	3.60	3.65	3.80	4.10	26	4.30	3.72	3.60	3.62	3.84	3.90
11	4.75	3.90	3.60	3.65	3.76	4.10	27	4.30	3.72	3.60	3.62	4.00	3.90
12	4.82	3.81	3.67	3.65	7.53	4.10	28	4.25	3.70	3.65	3.65	4.00	3.90
13	4.77	3.81	3.56	3.72	5.40	4.05	29	4.12	3.70	3.60	3.74	5.03	3.90
14	4.65	3.72	3.58	3.65	4.53	4.02	30	4.01	3.65	4.20	3.80	6.10	3.90
15	4.42	3.75	3.80	3.65	4.30	4.10	31	4.02	3.65	.....	3.82	.....	3.90
16	4.55	3.92	3.62	3.60	4.12	4.05							

Tennessee River at Chattanooga, Tennessee, for 1890.

[Furnished by L. M. Pindell, observer in charge, United States Weather Bureau.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.9	8.0	40.2	10.0	7.5	6.1	3.2	5.8	7.6	9.4	6.8	2.4
2	5.2	7.3	42.5	9.8	7.1	6.6	2.9	5.2	5.6	8.1	6.6	2.4
3	5.1	7.3	41.0	9.4	6.7	5.3	2.9	4.7	5.7	7.7	5.7	2.3
4	5.0	7.4	34.4	9.7	6.8	5.3	3.0	4.7	4.0	7.2	5.3	2.3
5	5.0	7.2	23.0	12.2	7.0	5.2	3.0	4.8	3.6	6.4	5.0	2.3
6	4.8	7.8	15.1	14.0	7.5	5.3	3.0	4.5	3.2	5.7	4.6	2.5
7	4.7	8.3	14.2	13.6	8.9	5.2	3.0	5.2	3.6	5.2	4.4	2.8
8	4.6	11.5	14.4	13.4	9.1	4.9	2.9	5.7	3.2	5.2	4.3	2.9
9	4.7	19.3	12.8	11.9	8.7	4.7	2.8	6.6	2.8	5.5	4.0	7.1
10	4.9	20.4	11.2	10.5	8.7	4.5	2.7	7.5	2.8	5.3	3.9	8.1
11	4.7	17.8	10.0	9.6	8.1	4.5	2.7	7.2	3.0	4.8	3.8	8.2
12	4.6	14.7	9.2	8.7	7.7	4.4	3.0	6.3	3.4	4.6	3.6	7.7
13	4.6	12.0	8.6	8.0	7.2	4.0	2.7	5.8	3.6	4.4	3.5	7.4
14	4.0	10.0	8.7	7.5	6.7	3.9	2.5	5.2	4.6	4.2	3.4	6.4
15	4.6	9.8	9.7	7.1	6.6	4.0	2.3	4.8	4.0	3.9	3.3	3.7
16	5.4	9.6	13.7	6.9	7.8	4.1	2.1	4.2	4.0	3.7	3.2	4.2
17	7.2	9.0	15.1	7.1	9.3	4.0	2.0	3.8	3.7	3.7	3.2	3.9
18	9.2	9.3	14.9	9.4	8.6	3.9	2.2	3.7	4.0	3.7	3.0	3.9
19	8.2	8.5	13.0	16.6	7.9	3.7	4.7	3.3	5.3	4.2	3.2	4.0
20	7.5	7.8	11.7	20.4	8.8	3.6	4.7	3.1	3.7	4.0	3.1	4.0
21	7.0	7.3	12.4	18.2	10.7	3.7	4.1	2.6	3.7	4.0	3.1	3.9
22	9.6	7.1	14.0	14.3	11.9	3.8	3.5	2.5	5.8	3.8	3.1	3.9
23	13.0	7.2	20.0	11.3	11.9	3.7	3.2	3.8	3.5	5.3	2.9	3.9
24	12.3	7.4	25.5	9.6	11.6	3.8	3.2	4.0	3.3	7.2	2.8	3.9
25	11.7	12.1	27.2	8.7	9.2	4.0	4.1	3.3	3.4	8.8	2.8	4.3
26	10.0	18.7	26.0	8.4	7.8	4.0	5.9	3.8	4.0	9.2	2.7	4.6
27	8.3	26.4	21.4	8.4	7.4	3.9	7.5	3.6	4.3	9.5	2.6	9.4
28	7.3	34.8	15.4	8.5	8.0	3.9	7.7	3.0	4.0	8.6	2.6	12.5
29	6.6	.....	13.0	8.4	8.1	3.5	7.0	3.8	3.8	7.6	2.5	12.9
30	7.7	.....	11.9	8.1	7.4	3.1	6.3	5.4	5.3	7.1	2.4	12.4
31	8.3	.....	10.7	.....	6.8	.....	6.2	6.5	.....	7.0	.....	9.3

Tennessee River at Chattanooga, Tennessee, for 1891.

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.7	9.8	18.6	15.4	5.9	5.8	3.9	8.3	5.4	1.8	1.3	3.7
2	7.8	13.2	17.5	16.3	5.7	5.6	3.8	10.3	4.7	1.9	1.3	3.2
3	9.9	16.1	15.6	16.3	5.6	5.3	3.6	15.1	4.3	1.9	1.3	2.9
4	14.1	19.8	13.3	15.7	5.5	4.8	3.6	16.4	4.2	1.8	1.2	2.8
5	15.5	22.6	15.4	15.1	5.2	4.4	3.6	12.0	5.1	1.8	1.2	5.6
6	15.2	21.6	20.0	12.6	5.1	4.1	3.6	8.7	5.1	1.7	1.2	6.1
7	10.4	18.3	23.6	11.6	4.9	3.9	3.4	6.9	5.2	1.7	1.2	6.6
8	8.2	16.9	29.1	10.8	4.7	4.1	3.4	5.8	5.2	1.6	1.2	8.6
9	7.1	14.5	34.5	9.8	4.6	4.6	3.3	5.1	5.8	1.7	1.2	10.8
10	6.3	21.0	37.5	9.6	4.5	4.7	4.5	4.6	4.9	1.7	1.2	10.9
11	6.5	27.8	38.9	9.8	4.4	5.5	5.1	4.4	4.4	1.8	1.5	10.2
12	8.9	34.3	37.6	9.9	4.3	7.0	4.4	4.0	3.9	1.8	1.7	8.5
13	10.7	36.5	33.5	10.6	4.2	6.5	3.9	4.0	3.6	1.7	2.7	6.8
14	10.0	37.5	27.0	11.3	4.1	5.7	3.5	3.9	3.5	1.7	3.6	5.7
15	9.2	35.5	22.2	12.2	4.2	5.5	3.1	3.8	3.5	1.7	4.1	5.1
16	7.3	29.0	19.8	10.8	4.2	5.7	2.9	3.6	3.5	1.6	3.5	5.0
17	7.8	21.1	18.1	9.4	4.5	5.8	2.8	3.5	3.5	1.6	2.8	5.2
18	7.5	19.7	15.3	8.4	4.7	6.1	2.7	3.4	3.2	1.5	2.5	5.3
19	7.5	18.2	13.5	8.2	4.7	6.8	4.1	3.0	2.9	1.5	2.4	4.8
20	7.6	16.5	12.3	7.9	4.6	7.3	5.0	3.0	2.7	1.5	2.5	4.5
21	7.3	15.5	11.3	7.9	4.5	6.8	4.5	3.4	2.6	1.5	2.3	4.2
22	8.2	18.8	10.8	7.6	4.3	6.8	4.0	4.0	2.5	1.5	2.4	4.0
23	12.5	24.0	10.7	7.4	4.1	6.5	3.8	4.6	2.4	1.5	3.0	3.8
24	15.3	27.7	10.8	7.4	4.0	7.1	3.6	5.5	2.3	1.5	4.6	3.7
25	14.0	29.0	10.6	7.5	3.8	7.4	3.5	5.6	2.2	1.5	6.2	4.1
26	13.6	26.7	10.4	7.5	3.9	7.6	3.5	7.7	2.2	1.5	6.7	4.9
27	11.2	20.6	10.5	7.4	4.0	6.2	3.5	8.2	2.1	1.5	6.3	8.1
28	9.7	19.0	14.1	7.2	4.1	4.9	3.6	8.1	2.0	1.5	5.6	10.2
29	7.9	.....	13.6	6.5	4.1	4.3	3.7	7.0	1.9	1.4	4.7	9.6
30	7.9	.....	13.0	6.2	4.7	4.1	3.8	6.4	1.9	1.4	4.0	8.4
31	8.9	.....	13.1	.....	5.3	.....	5.7	6.1	.....	1.4	.....	7.8

Tennessee River at Chattanooga, Tennessee, for 1892.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.6	6.5	5.7	9.1	8.7	5.6	6.6	4.2	2.1	2.2	1.1	4.1
2	6.6	6.2	5.6	8.3	8.2	5.4	5.6	4.1	1.8	2.0	1.2	4.0
3	8.1	6.0	5.5	7.4	7.6	5.5	5.5	4.2	1.7	1.9	1.2	3.8
4	8.8	5.8	5.3	6.8	7.3	5.8	5.4	4.0	1.5	1.8	1.6	3.7
5	8.7	5.5	5.1	6.5	7.4	8.8	6.6	4.1	1.3	1.7	2.0	3.6
6	8.4	5.4	5.0	8.5	7.0	9.2	8.9	4.9	2.2	1.6	2.3	3.6
7	9.0	5.3	4.9	21.7	6.6	9.3	11.2	4.2	2.1	1.6	2.4	3.3
8	9.8	5.8	5.0	31.6	6.3	8.7	11.8	3.8	2.0	1.5	2.4	3.2
9	10.0	8.1	6.0	34.2	6.2	8.6	10.1	3.5	2.0	1.5	2.9	3.2
10	9.3	11.5	7.1	34.3	5.9	8.3	8.6	3.3	1.9	1.5	4.4	3.0
11	8.1	11.3	8.0	31.0	5.5	7.8	9.0	3.3	2.0	1.5	5.9	2.9
12	8.3	10.5	7.9	26.6	5.7	8.0	9.5	3.1	1.8	1.5	6.6	2.7
13	11.2	8.9	7.6	18.0	5.7	8.1	9.4	3.5	2.1	1.4	7.0	2.6
14	22.9	7.7	7.6	12.9	5.5	7.8	8.9	3.6	2.1	1.4	4.4	2.6
15	32.9	7.2	6.8	11.7	5.3	6.0	8.7	3.7	2.1	1.4	4.2	3.3
16	37.1	7.4	6.2	10.9	5.2	5.3	8.5	3.5	3.1	1.4	4.8	3.4
17	37.9	8.0	5.9	10.0	5.1	4.8	8.4	3.1	4.5	1.4	5.6	5.3
18	35.2	7.9	6.5	9.4	4.8	4.4	8.1	2.9	4.1	1.3	6.2	8.1
19	26.3	7.5	7.5	8.8	5.1	4.4	7.5	2.8	3.5	1.3	6.4	8.7
20	18.7	7.7	8.2	12.3	5.5	4.3	7.2	2.8	3.0	1.2	6.2	8.4
21	19.0	7.9	8.2	16.2	6.1	7.0	6.9	3.0	2.8	1.2	5.5	9.1
22	19.0	8.9	7.8	16.3	6.5	7.8	6.2	2.9	3.0	1.2	4.8	9.3
23	17.4	8.9	7.6	15.5	6.9	7.4	5.6	2.9	2.6	1.2	4.4	8.9
24	14.9	8.4	8.4	14.8	7.1	7.1	5.4	3.0	2.3	1.2	4.2	7.8
25	12.2	7.9	9.6	13.5	7.6	6.9	5.2	2.7	2.3	1.2	3.9	6.7
26	10.5	7.5	9.5	13.7	7.8	6.8	5.0	2.8	3.6	1.1	3.4	5.8
27	9.7	6.7	10.0	13.6	6.7	6.7	4.6	3.2	3.6	1.1	3.1	5.2
28	8.5	6.4	10.6	10.4	6.2	7.3	4.5	3.6	3.1	1.1	3.0	4.8
29	7.7	5.9	10.3	9.1	5.8	7.5	4.3	4.4	2.6	1.1	3.0	4.3
30	6.9	.....	9.7	8.8	5.7	7.2	4.1	3.8	2.4	1.1	3.6	3.9
31	6.8	.....	9.4	.....	5.6	.....	3.8	3.3	.....	1.1	.....	3.3

Tennessee River at Chattanooga, Tennessee, for 1893.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.4	10.4	8.4	5.5	10.2	7.4	3.9	2.6	8.4	2.6	3.1	2.5
2	3.8	12.1	9.1	5.3	9.6	8.0	3.8	2.5	6.8	2.5	3.0	3.9
3	4.7	10.6	8.9	5.1	11.0	10.0	4.2	3.1	5.0	2.4	2.8	3.7
4	5.7	8.6	8.9	5.1	18.4	8.1	5.2	3.5	6.2	2.4	2.7	4.1
5	5.6	8.0	8.7	5.1	24.5	6.6	4.8	3.3	6.0	2.6	2.6	4.3
6	5.3	7.7	9.0	5.2	28.2	8.3	3.9	3.2	4.9	2.5	2.5	4.7
7	5.2	7.0	9.1	5.4	30.0	16.0	3.8	4.9	4.3	2.9	2.4	4.7
8	4.7	6.5	8.8	5.4	28.2	20.7	3.5	5.0	3.5	3.1	2.4	4.5
9	4.0	6.1	8.8	5.1	18.0	19.1	3.4	4.1	3.2	2.9	2.3	4.1
10	3.8	6.2	9.4	5.1	12.8	15.2	3.6	3.8	2.8	2.9	2.4	4.0
11	3.4	8.5	11.1	5.1	11.7	11.8	3.4	3.3	2.8	2.6	2.5	3.7
12	2.9	14.7	11.7	5.0	10.4	8.9	3.4	3.0	3.7	2.5	4.8	3.2
13	2.9	21.8	11.5	4.8	9.4	7.3	3.3	2.7	5.8	2.4	3.8	3.1
14	(a)	23.6	12.0	10.2	8.8	6.8	3.2	2.5	10.9	2.5	3.6	3.0
15	(a)	22.6	10.6	12.1	8.1	6.5	3.0	2.8	12.7	2.0	3.5	2.9
16	(a)	21.3	9.5	10.4	7.8	6.2	2.8	2.9	9.6	1.7	3.0	3.0
17	(a)	23.6	8.4	8.6	9.4	5.6	2.7	3.8	8.0	9.6	2.8	3.2
18	(a)	29.4	7.6	7.4	10.4	5.4	2.8	5.2	7.0	6.4	2.7	3.5
19	(a)	32.4	7.0	6.5	8.9	5.3	3.0	4.9	6.1	5.7	2.5	3.8
20	(a)	33.4	6.7	6.4	7.7	5.2	3.2	4.0	5.1	5.2	2.6	3.9
21	(a)	32.8	6.3	7.2	7.4	5.4	3.5	2.9	4.2	4.1	2.6	3.9
22	(a)	28.5	6.0	7.2	6.7	5.6	3.6	2.6	3.6	3.4	2.6	3.5
23	2.9	18.2	5.8	7.1	6.1	5.7	4.6	2.4	3.4	3.1	2.5	3.3
24	3.1	12.3	5.7	6.8	5.7	5.4	5.2	2.3	3.2	2.8	2.5	3.1
25	3.1	10.4	6.4	6.7	5.4	5.9	5.5	2.2	3.0	3.1	2.4	2.9
26	3.4	9.3	6.8	6.0	5.2	5.6	3.7	1.9	2.9	3.3	2.5	2.8
27	3.7	8.4	6.8	5.7	5.0	5.2	3.4	1.8	2.7	4.9	2.6	2.7
28	3.8	8.2	6.3	7.0	4.6	5.1	2.9	1.6	2.6	4.6	2.8	2.6
29	4.4	.....	5.9	9.5	5.4	4.7	3.7	1.6	2.4	4.0	2.7	2.5
30	5.3	.....	5.8	10.4	6.5	4.1	2.6	1.7	2.5	3.5	2.5	2.7
31	7.1	.....	5.7	.....	7.4	.....	2.6	1.6	.....	3.2	.....	3.1

a Frozen at gage.

Tennessee River at Chattanooga, Tennessee, for 1894.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.9	5.1	7.7	5.0	3.9	3.8	4.4	2.9	4.0	0.9	1.4	1.0
2	3.4	5.0	8.2	4.8	3.8	3.6	4.0	2.9	3.8	.9	1.7	1.0
3	3.8	4.9	9.4	5.4	3.7	3.5	3.7	2.9	3.0	1.0	2.3	.9
4	3.9	5.5	9.7	5.3	3.7	3.4	4.4	2.8	2.6	1.5	1.6	.9
5	3.5	21.9	9.5	6.8	3.6	3.3	4.2	2.9	2.1	1.8	1.4	.9
6	3.1	25.5	9.3	6.9	3.5	3.2	3.7	3.0	2.0	1.8	1.5	.9
7	4.9	23.9	8.5	7.2	3.4	2.9	3.2	2.9	1.8	1.5	1.5	.9
8	6.1	19.7	8.2	7.4	3.3	2.8	3.3	2.9	1.7	1.3	1.3	.9
9	9.3	16.1	7.9	6.6	3.4	2.6	3.1	3.0	1.5	1.1	1.2	1.1
10	9.0	16.0	7.2	5.7	3.3	2.5	3.3	2.6	1.4	1.0	1.1	1.2
11	8.5	16.7	6.9	5.9	3.2	2.5	3.7	2.3	1.4	.8	1.0	1.6
12	7.9	15.4	6.6	7.2	4.7	2.4	3.3	2.1	1.4	.9	1.0	3.8
13	8.3	15.2	6.7	8.5	5.1	2.3	2.7	1.9	1.3	1.2	.9	8.6
14	8.0	14.1	7.2	7.8	4.8	2.3	2.4	1.8	1.2	1.9	.8	11.1
15	7.8	12.2	7.0	7.2	4.3	2.2	2.1	2.0	1.5	2.4	.8	11.2
16	7.8	10.3	6.9	6.7	4.0	2.1	1.9	3.6	1.8	2.1	.8	10.8
17	7.1	9.5	6.8	6.3	4.1	2.0	1.8	4.6	1.8	1.7	.8	8.6
18	7.2	8.6	7.3	5.5	5.2	2.1	2.8	3.5	2.0	1.4	.7	6.6
19	6.3	8.4	7.4	5.0	5.0	2.4	2.4	3.0	2.0	1.1	.8	4.7
20	6.0	8.3	7.7	5.1	5.4	2.5	2.4	3.1	1.6	1.0	.9	4.2
21	5.3	8.5	7.1	4.9	5.6	2.6	3.3	3.6	1.5	.9	.9	3.6
22	5.0	8.7	8.8	4.8	6.2	2.5	3.7	3.7	1.5	.8	.9	3.2
23	5.0	8.8	8.7	4.7	6.8	2.3	3.8	4.0	1.8	.8	1.0	2.8
24	5.2	8.2	8.1	4.6	6.9	2.2	3.4	3.6	1.8	.8	1.0	2.7
25	5.3	7.9	7.7	4.5	7.1	2.2	4.0	3.0	1.6	.8	1.1	2.5
26	5.2	7.6	7.3	4.3	6.7	2.5	1.4	2.6	1.3	.8	1.2	2.4
27	5.4	7.7	7.0	4.2	6.0	2.6	3.9	2.2	1.1	.7	1.2	4.2
28	5.4	7.7	6.5	4.1	5.6	2.7	3.8	2.7	1.0	.7	1.1	6.9
29	5.1	.....	5.9	4.0	5.1	2.9	3.6	2.4	.9	.7	1.1	8.4
30	5.0	.....	5.7	4.0	4.7	4.3	3.3	2.7	.8	1.0	1.1	7.9
31	4.9	.....	5.2	.....	4.2	.....	3.3	4.3	.....	1.1	.....	5.8

Tennessee River at Chattanooga, Tennessee, for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.7	7.6	6.8	7.8	6.0	5.6	3.2	4.4	3.3	0.9	1.1	1.4
2	3.9	7.2	7.3	7.4	5.8	5.2	3.4	4.1	3.4	.8	1.2	1.5
3	3.3	7.3	12.1	6.8	5.5	4.8	3.8	3.8	3.2	.8	1.3	1.4
4	3.2	7.5	18.2	6.5	5.4	4.5	4.0	3.5	3.1	.8	1.6	1.4
5	3.1	7.6	19.9	6.3	5.7	4.2	4.5	3.4	2.9	.8	1.6	1.4
6	3.1	7.4	18.2	6.2	6.0	4.4	5.0	3.0	2.8	.8	1.3	1.6
7	3.3	6.9	13.4	6.0	6.5	4.6	5.0	3.2	2.8	.8	1.3	1.5
8	4.0	6.5	10.5	9.6	7.0	5.2	5.1	3.3	2.8	.9	1.2	1.4
9	10.9	6.4	9.2	10.7	8.2	5.1	5.5	3.3	2.5	.8	1.1	1.3
10	20.5	5.0	8.6	11.4	8.6	4.6	5.7	3.0	2.4	.9	1.2	1.3
11	28.5	4.0	8.1	13.0	9.0	4.2	5.1	3.0	2.3	1.0	1.3	1.4
12	32.1	3.3	7.5	12.5	8.8	3.8	4.4	3.9	2.4	1.0	1.7	1.5
13	31.2	4.2	7.8	10.4	8.9	3.6	3.8	3.2	2.5	1.0	2.1	1.8
14	28.3	(a)	8.0	8.8	9.5	3.5	3.4	2.9	2.4	1.0	2.4	1.9
15	19.5	4.3	8.7	7.9	9.0	3.4	3.2	2.8	2.3	.9	2.2	2.0
16	12.3	4.7	9.4	7.4	8.2	3.4	3.2	2.7	2.2	1.0	2.0	1.9
17	10.9	4.7	9.2	7.0	7.7	3.8	3.7	3.1	2.1	1.0	1.9	1.8
18	10.0	4.2	9.6	9.0	7.1	3.7	3.6	4.3	2.3	1.0	1.8	1.7
19	9.7	4.7	9.4	11.8	7.0	3.5	3.3	4.9	2.2	.9	1.7	1.6
20	9.1	4.6	8.9	11.8	7.2	3.2	3.0	5.7	2.0	.9	1.5	1.5
21	9.6	5.1	14.3	9.9	7.1	3.1	2.7	5.3	2.1	.8	1.3	1.6
22	10.2	5.6	20.6	8.6	6.7	3.2	2.7	6.1	1.9	.8	1.1	2.1
23	9.9	6.1	22.7	7.7	6.5	3.1	2.5	5.3	1.6	.7	1.3	3.3
24	9.1	6.7	22.0	7.1	5.8	3.0	2.4	4.8	1.4	.7	1.4	4.2
25	10.8	6.8	18.2	6.7	5.6	2.9	2.4	4.6	1.3	.7	1.3	4.6
26	10.8	6.5	13.0	6.3	5.6	2.9	2.9	4.7	1.3	.7	1.3	4.3
27	10.0	6.3	11.3	6.0	7.0	2.6	3.8	4.2	1.2	.7	1.3	4.2
28	9.3	6.3	10.6	6.0	7.5	2.5	10.2	3.7	1.1	.7	1.3	4.5
29	8.8	.....	9.5	5.0	7.4	2.5	10.4	3.5	1.0	.7	1.3	5.2
30	8.6	.....	8.9	5.9	6.7	2.6	7.4	3.7	0.9	.7	1.5	4.7
31	8.4	.....	8.4	.....	6.0	.....	5.3	3.4	.....	1.0	.....	4.7

a Frozen.

Tennessee River at Chattanooga, Tennessee, for 1896.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.9	4.4	4.1	14.8	3.4	2.6	3.3	5.5	2.4	2.5	1.2	2.4
2	5.0	6.2	3.9	27.7	3.4	3.0	3.2	5.2	2.1	2.3	1.2	2.5
3	4.9	10.0	3.8	34.4	3.4	4.4	3.1	4.8	1.9	2.6	1.3	2.5
4	4.9	11.6	3.7	38.8	3.5	5.7	3.2	4.6	1.8	3.0	1.5	2.6
5	4.7	10.5	3.6	40.5	4.0	5.2	3.3	4.5	1.6	2.7	1.5	2.6
6	4.3	9.3	3.5	36.9	4.6	4.7	3.2	4.9	1.6	2.6	1.6	2.7
7	3.6	11.8	3.4	23.3	4.6	4.1	3.6	5.0	1.5	2.1	2.3	2.9
8	3.3	14.0	3.5	11.6	4.3	3.5	5.0	4.2	2.0	1.7	3.5	3.0
9	3.2	13.8	3.5	9.0	4.0	3.5	3.9	3.8	2.8	1.5	4.2	2.8
10	3.2	13.2	3.4	8.0	3.7	4.5	14.2	3.4	2.7	1.4	4.1	2.8
11	3.1	12.8	3.6	7.2	3.4	7.0	21.1	3.3	2.4	1.2	3.3	2.7
12	3.1	11.4	3.6	6.7	3.1	6.3	21.6	3.4	2.0	1.2	3.2	2.6
13	2.9	10.1	3.8	6.2	2.9	5.1	15.6	3.2	1.8	1.2	5.8	2.4
14	2.7	11.1	3.8	5.8	2.8	4.3	11.5	3.2	1.6	1.2	7.3	2.6
15	2.6	12.8	3.7	5.5	2.7	3.6	11.2	3.1	1.6	1.5	6.5	4.1
16	2.4	13.6	3.8	5.2	2.6	3.2	11.4	3.0	1.5	1.7	5.5	6.5
17	2.3	12.5	5.5	5.0	2.5	3.0	11.0	3.0	1.3	1.6	4.9	6.6
18	2.3	11.0	10.1	4.8	2.4	2.8	13.9	2.9	1.4	1.6	4.3	6.3
19	2.3	9.0	13.1	4.2	2.4	2.9	12.5	2.7	1.4	1.7	3.8	6.4
20	2.3	7.6	15.7	4.4	2.2	3.1	9.6	2.6	1.3	1.6	3.4	6.8
21	2.3	6.7	13.8	4.2	2.1	3.7	7.6	2.4	1.2	1.6	3.0	7.0
22	2.5	6.0	11.2	4.1	2.1	3.5	6.5	2.4	1.2	1.4	2.8	7.2
23	3.1	5.4	9.5	4.1	2.5	3.5	8.5	2.2	1.3	1.2	2.5	7.3
24	5.0	4.9	8.4	4.0	3.2	3.3	8.8	2.2	1.4	1.2	2.4	7.0
25	6.5	4.7	7.9	4.0	3.6	3.1	8.6	2.8	1.6	1.2	2.3	6.6
26	8.2	4.6	7.5	3.8	3.8	2.9	7.8	2.6	2.0	1.2	2.2	5.9
27	8.0	4.5	7.2	3.8	3.2	2.6	11.1	2.7	1.7	1.2	2.1	5.3
28	7.0	4.4	6.7	3.8	3.1	2.6	12.2	3.2	1.5	1.2	2.2	4.8
29	6.0	4.2	6.2	3.6	2.8	2.8	9.3	4.0	1.5	1.1	5.3	4.4
30	5.3	.....	5.8	3.6	2.7	3.0	7.2	3.6	2.7	1.1	9.4	3.7
31	4.8	.....	7.7	.....	2.5	.....	6.2	2.8	.....	1.3	.....	3.0

Missouri River at Townsend, Montana.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	92.3	91.6	88.8	88.9	89.5	91.8	92.0	89.1	88.9	88.9	89.0	91.5
2	92.2	91.6	90.9	88.9	89.5	92.2	92.0	89.1	89.0	88.9	89.0	91.8
3	91.8	91.6	90.7	88.9	89.5	92.6	91.8	89.1	88.9	88.9	88.9	92.2
4	91.4	91.6	90.7	88.9	89.5	93.0	91.6	89.1	88.9	88.9	88.9	92.6
5	91.4	91.6	90.7	88.9	89.6	93.6	91.4	89.1	88.9	88.9	88.9	92.9
6	91.6	91.6	90.7	88.9	89.7	93.7	91.2	89.1	88.9	88.9	88.9	92.9
7	91.6	91.6	90.7	88.9	89.8	93.8	91.0	89.1	88.9	88.9	88.9	92.9
8	91.6	91.6	90.7	89.0	89.9	93.7	91.0	89.1	88.9	88.9	88.9	92.9
9	91.8	91.6	90.7	89.0	90.0	93.8	90.7	89.1	88.9	88.9	89.0	92.9
10	91.8	91.5	90.7	89.0	90.0	93.9	90.6	89.1	89.0	88.9	89.0	92.9
11	92.0	91.5	90.7	89.0	89.9	94.2	90.4	89.1	89.1	89.0	89.1	92.9
12	91.9	91.5	92.2	89.0	89.8	94.5	90.4	89.0	89.1	88.9	89.1	92.9
13	91.9	91.5	90.0	88.9	89.8	94.4	90.5	88.9	89.1	88.9	89.2	92.8
14	91.9	91.5	89.4	88.9	89.7	94.4	90.6	88.9	89.1	88.9	89.2	92.8
15	91.9	91.5	89.0	88.9	89.6	94.5	90.8	88.9	89.1	88.9	89.2	92.6
16	91.9	91.5	88.8	88.9	89.6	94.6	90.6	88.9	89.1	88.9	83.2	92.2
17	91.9	91.5	88.6	88.9	89.6	94.7	90.5	88.9	89.1	88.9	89.2	91.9
18	91.9	91.5	88.6	88.9	89.7	91.8	90.2	88.9	89.0	88.9	89.1	91.4
19	91.8	91.5	88.8	88.9	89.7	94.8	90.0	88.8	89.0	88.9	89.1	91.4
20	91.8	91.5	89.0	88.9	89.8	94.9	89.8	88.8	89.0	88.9	89.1	91.4
21	91.8	91.5	89.1	89.0	89.8	94.7	89.7	88.8	89.0	88.9	89.1	89.8
22	91.8	90.5	89.1	89.0	89.8	94.6	89.7	88.8	89.1	88.9	89.1	89.7
23	91.8	90.4	89.1	89.1	90.0	94.5	89.7	88.8	89.1	88.8	89.1	89.5
24	91.8	90.3	89.1	89.1	90.0	94.2	89.6	88.8	89.1	88.8	89.1	89.3
25	91.8	89.8	89.1	89.1	90.2	93.8	89.6	88.8	89.1	88.8	89.1	89.3
26	91.8	89.6	89.1	89.1	90.4	93.4	89.5	88.8	89.1	88.8	90.6	89.2
27	91.7	89.2	89.1	89.2	90.4	92.8	89.4	88.7	89.1	88.8	90.6	89.2
28	91.7	88.4	89.1	89.2	90.6	92.6	89.4	88.7	89.0	88.9	90.6	89.1
29	91.7	88.8	89.0	89.4	91.1	92.4	89.3	88.7	88.9	88.9	90.6	89.0
30	91.6	.....	88.9	89.5	91.5	92.2	89.3	88.7	88.9	89.0	90.8	88.0
31	91.6	.....	88.9	.....	91.6	.....	89.2	88.8	.....	89.0	.....	88.9

West Gallatin River, near Salesville, Montana.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	3.60	2.90	2.70	.....	3.25	5.45	5.55	3.60	3.40	3.40	3.10
2	3.70	2.90	2.60	.....	3.25	6.05	5.45	3.70	3.40	3.40	3.10
3	3.60	2.90	2.70	.....	3.30	5.95	5.30	3.80	3.40	3.40	3.10
4	3.50	2.90	2.70	.....	3.45	5.85	5.15	3.75	3.40	3.35	3.10
5	3.85	2.90	2.80	.....	3.45	5.05	5.05	3.70	3.40	3.40	3.10
6	3.90	2.90	2.80	.....	3.45	5.60	4.95	3.70	3.30	3.40	3.10
7	4.00	2.90	2.85	.....	3.40	5.60	4.95	3.70	3.30	3.30	3.05
8	3.75	2.90	.....	.....	3.35	6.00	4.85	3.70	3.30	3.35	3.05
9	3.40	2.90	.....	.....	3.35	6.95	4.75	3.65	3.30	3.45	3.15
10	3.10	2.90	.....	3.00	3.35	7.85	4.70	3.55	3.30	3.50	3.20
11	3.00	3.00	.....	3.00	3.35	7.10	4.70	3.50	3.40	3.40	3.10
12	2.90	3.00	.....	3.00	3.35	6.65	4.75	3.50	3.40	3.30	3.10
13	2.90	3.00	.....	2.90	3.30	6.75	4.85	3.50	3.40	3.30	3.15
14	2.90	3.00	.....	3.00	3.30	7.15	4.75	3.50	3.45	3.30	3.20
15	3.00	3.00	.....	2.90	3.30	7.20	4.60	3.50	3.45	3.30	3.20
16	3.00	3.00	.....	2.90	3.30	7.50	4.45	3.50	3.40	3.30	3.20
17	3.00	3.00	.....	2.90	3.20	7.50	4.30	3.50	3.40	3.20	3.20
18	3.00	3.00	.....	2.90	3.20	7.90	4.25	3.50	3.40	3.20	3.10
19	3.00	3.00	.....	2.90	3.20	7.85	4.20	3.50	3.40	3.20	3.10
20	2.90	3.00	.....	2.90	3.25	7.35	4.10	3.40	3.40	3.20	3.10
21	2.90	3.10	.....	2.90	3.30	6.95	4.00	3.50	3.30	3.20	3.05
22	2.90	3.10	.....	3.00	3.40	6.50	4.00	3.45	3.30	3.20	3.20
23	3.00	2.95	.....	3.00	3.50	6.20	4.00	3.40	3.30	3.20	3.20
24	3.00	2.95	.....	3.00	4.10	6.00	3.90	3.40	3.30	3.20	3.10
25	3.00	2.95	.....	3.15	4.10	5.90	3.90	3.40	3.50	3.20	3.00
26	3.00	3.00	.....	3.20	4.00	5.85	3.80	3.35	3.45	3.20	2.80
27	2.90	2.95	.....	3.20	4.10	5.80	3.70	3.30	3.40	3.20	2.70
28	2.90	2.90	.....	3.30	4.40	5.55	3.70	3.30	3.40	3.20	2.70
29	2.90	2.75	.....	3.30	4.40	5.50	3.85	3.30	3.30	3.10	2.70
30	2.90	.....	.....	3.30	3.90	5.50	3.70	3.30	3.40	3.10	2.70
31	2.90	.....	.....	.....	4.90	.....	3.60	3.40	.....	3.10	.....

Middle Creek at Bozeman, Montana.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1							
2		0.25					
3				0.90			
4	0.10		0.90				
5						0.20	
6							
7				1.05			
8			1.15		0.35		
9		.33					
10							
11					.30		
12			1.20			.28	
13							
14						.27	
15				.88			
16		.25	1.30				
17					.28		0.21
18						.22	
19				.60		.21	
20							
21							
22		.48				.20	
23			1.10				
24	.20	.80					
25					.23		
26							
27		.93					
28					.22		
29				.43			
30		1.80					
31							

Gallatin River at Logan, Montana.

Day.	Jan.	Feb.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	(a)	1.00		1.30	3.20	2.75	1.20	1.00	1.00		
2	(a)	.90		1.20	3.65	2.65	1.10	1.00	1.00		
3	(a)	.90		1.20	3.80	2.50	1.10	1.00	1.00		
4	(a)	1.00		1.20	3.95	2.50	1.10	1.00	1.05	1.00	
5	(a)	.90		1.40	3.80	2.35	1.10	1.00	1.10		
6	(a)	.90		1.55	3.75	2.20	1.10	.90	1.05		
7	(a)	1.00		1.50	3.75	2.00	1.10	.90	1.00	1.00	
8	(a)	1.05		1.45	3.70	1.90	1.10	.90	1.00		
9	(a)	1.00	1.10	1.50	4.20	1.80	1.10	.90	1.00		
10	(a)	1.00	1.10	1.60	5.10	1.65	1.05	1.00	1.00		
11	(a)	1.20	1.10	1.50	5.15	1.50	1.00	1.10	1.00	1.00	1.63
12	(a)	.95	1.05	1.50	4.50	1.50	1.00	1.20	1.00		1.10
13	(a)	.90	1.00	1.50	4.50	1.75	1.00	1.10	1.00		
14	(a)	.90	1.10	1.40	4.65	1.60	1.00	1.05	1.00	1.00	
15	(a)	.90	1.10	1.40	4.75	1.70	1.00	1.00	1.00		
16	(a)	.90	1.10	1.30	5.20	1.60	1.00	1.00	.95		1.10
17	(a)	.90	1.00	1.30	5.45	1.50	1.00	1.00	.95		
18	(a)	.90	1.00	1.30	5.60	1.40	1.00	1.00	1.00	1.00	
19	(a)	.90	1.00	1.30	5.10	1.40	1.00	.95	1.00		1.10
20	(a)	.90	1.00	1.30	4.85	1.40	1.00	.95	1.00		
21	(a)	1.00	1.00	1.30	4.50	1.40	1.00	.95	1.00	1.00	
22	(a)	.95	1.00	1.30	4.40	1.30	1.00	.95	1.00		
23	(a)	.90	1.00	1.30	4.25	1.30	1.00	.95	.95		
24	(a)	.95	1.00	1.35	4.05	1.20	1.00	.95	1.00	1.00	1.00
25	(a)	1.00	1.05	1.70	3.80	1.10	1.00	1.10	1.00		
26	(a)	1.00	1.10	1.80	3.55	1.10	1.00	1.15	1.00		1.00
27	(a)	1.00	1.10	1.80	3.40	1.10	1.00	1.05	1.00		
28	1.10	1.00	1.20	2.05	3.25	1.10	1.00	1.05	1.00		
29	1.10	1.00	1.20	2.30	3.10	1.20	1.00	1.05	1.00		
30	1.10		1.20	2.50	2.95	1.20	1.00	1.00	1.00		
31	1.00			2.70		1.20	1.00		1.00		

a Frozen.

Madison River at Threeforks, Montana.

Day.	Jan.	Feb.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	1.00	1.10	.....	0.30	1.35	2.10	0.80	0.50	0.45
2	.90	1.10	.....	.30	1.45	2.00	.80	.50	45
3	— .60	1.00	.....	.30	1.55	1.90	.70	.50	.48
4	— .60	1.00	.....	.30	1.75	1.85	.70	.50	.50
5	— .60	.90	.....	.30	1.95	1.80	.70	.50	.50
6	— .60	.90	.....	.30	2.05	1.70	.70	.50	.50
7	— .45	.90	.....	.30	1.95	1.60	.60	.50	.50
8	— .35	.90	0.20	.35	1.95	1.50	.60	.50	.50
9	— .95	.90	.20	.40	2.30	1.45	.60	50	.48
10	+1.20	.90	.20	.40	2.55	1.40	.60	.50	.45
11	1.20	.80	.20	.30	2.65	1.30	.60	.50	.45
12	1.15	.80	.15	.30	2.75	1.35	.60	.53	.45
13	1.05	.80	.10	.30	2.70	1.35	.50	.55	.45
14	1.00	.80	.15	.30	2.75	1.30	.50	.55	.45
15	1.00	.80	.20	.25	2.80	1.30	.50	.55	.45
16	1.00	.80	.20	.20	2.95	1.30	.50	.50	.45
17	1.00	.80	.20	.20	3.05	1.30	.50	.50	.45
18	1.10	.80	.20	.20	3.15	1.20	.50	.45	.45
19	1.20	.80	.20	.20	3.20	1.15	.50	.45	.45
20	1.20	.80	.20	.25	3.10	1.10	.50	.45	.45
21	1.20	.80	.20	.30	3.10	1.05	.45	.45	.45
22	1.20	.80	.15	.35	3.00	1.00	.40	.45	.45
23	1.20	.80	.10	.40	2.85	.90	.40	.45	.45
24	1.20	.90	.10	.45	2.70	.90	.40	.45	.45
25	1.20	.90	.10	.55	2.55	.80	.40	.48	.45
26	1.20	.90	.20	.70	2.45	.80	.40	.50	.45
27	1.20	.90	.20	.75	2.40	.80	.40	.50	.45
28	1.20	.90	.20	.85	2.30	.70	.40	.50	.45
29	1.20	.80	.25	.95	2.20	.75	.40	.50	.40
30	1.10	.....	.30	1.05	2.15	.80	.40	.50	.40
31	1.10	.....	.....	1.20	.....	.80	.40	.....	.40

Jefferson River at Sappington, Montana.

Day.	Jan.	Sept.	Oct.	Nov.	Dec.	Day.	Jan.	Sept.	Oct.	Nov.	Dec.
1	(a)	.....	0.87	.....	.....	17	(a)	0.98	0.89	.....	.....
2	(a)	.....	.90	.....	.....	18	(a)	.97	.89	.....	2.10
3	(a)	.....	.89	0.96	.....	19	0.50	.90	.88	.....	.....
4	(a)	.....	.90	.....	.....	20	1.00	.90	.87	.....	.....
5	(a)	.....	.90	.....	.....	21	1.50	.87	.86	1.20	.....
6	(a)	.....	.90	.....	.....	22	1.00	.85	.87	.....	2.10
7	(a)	.....	.90	.81	.....	23	.....	.84	.87	1.20	.....
8	(a)	.....	.90	.....	.....	24	(a)	.86	.87	.....	.....
9	(a)	.....	.90	.....	.....	25	(a)	.89	.87	.....	.....
10	(a)	0.88	.90	.....	1.90	26	.....	.90	.86	.....	.....
11	(a)	.90	.90	.....	.....	27	.....	.90	.91	.....	.....
12	(a)	.92	.88	.....	.....	28	.....	.86	.93	.....	.....
13	(a)	.97	.87	.....	.....	29	.....	.84	.94	.....	.....
14	(a)	1.00	.87	.....	.....	30	.....	.86	.94	.....	.....
15	(a)	1.04	.87	.....	2.20	31	.....	.....	.93	.....	.....
16	(a)	1.00	.88	.....	.....						

a Frozen.

Little Goose Creek at Sheridan, Wyoming.

Day.	May.	June.	July.	Day.	May.	June.	July.	Day.	May.	June.	July.
1	1.70	1.75	0.70	12	2.00	1.30	0.80	23	1.50	0.75	0.80
2	1.70	2.45	.70	13	1.80	1.35	.80	24	1.95	.75	.85
3	1.70	2.30	.70	14	1.80	1.30	.85	25	2.10	.75	.80
4	1.80	2.50	.75	15	1.80	1.35	.80	26	1.70	.75	.80
5	1.80	2.30	.80	16	1.60	1.10	.85	27	1.70	.75	.80
6	2.00	2.00	.75	17	1.60	1.10	.80	28	1.85	.75	.90
7	2.30	1.80	.75	18	1.50	.90	.95	29	1.75	.75	.80
8	2.00	1.75	.75	19	1.40	.75	.80	30	2.50	.70	.80
9	2.20	1.90	.75	20	1.30	.75	.80	31	1.80	.....	.85
10	2.40	1.95	.80	21	1.40	.75	.80				
11	2.00	1.60	.80	22	1.55	.75	.80				

Big Goose Creek at Sheridan, Wyoming.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Day.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	2.90	3.70	2.25	2.35	1.50	17	2.60	2.00	3.15	2.10	1.90	1.50
2	.....	2.80	3.45	2.40	2.10	1.50	18	2.55	3.20	3.10	2.75	1.85	1.40
3	.....	2.80	5.10	2.40	2.20	1.60	19	2.50	3.50	3.05	2.10	1.90	1.40
4	.....	3.00	4.90	2.40	2.15	1.50	20	2.58	3.00	3.10	2.15	1.90	1.50
5	.....	3.20	4.20	2.40	2.35	1.50	21	2.55	3.00	3.15	2.30	1.90	1.60
6	.....	3.40	4.10	2.45	2.20	1.60	22	2.50	3.50	3.10	2.30	1.90	1.50
7	.....	3.20	3.75	2.30	2.15	1.70	23	2.50	3.50	2.80	2.60	1.90	1.40
8	.....	2.00	4.25	2.35	2.10	1.70	24	2.60	2.95	2.75	2.45	1.90	1.50
9	.....	3.60	4.25	2.25	2.10	1.50	25	2.60	3.90	2.80	2.35	1.80	1.40
10	2.55	3.40	4.90	2.10	2.20	1.60	26	2.75	3.10	2.70	2.25	1.80	1.50
11	2.60	3.20	4.10	2.20	1.65	1.70	27	2.85	3.45	2.65	2.40	1.80	1.60
12	2.55	3.40	3.60	2.20	1.90	1.70	28	2.95	3.50	2.65	2.40	1.80	1.50
13	2.45	.....	3.60	2.10	1.80	1.50	29	2.85	3.15	2.60	2.35	1.70	1.70
14	2.45	3.40	3.40	2.25	1.85	1.40	30	2.90	4.80	2.05	2.25	1.90	1.80
15	2.50	3.20	3.35	2.10	1.85	1.40	31	.....	4.40	.....	2.45	2.00	.....
16	2.60	3.40	3.30	2.00	1.90	1.30							

Clear Creek near Buffalo, Wyoming.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	1.35	0.80	1.00	0.56	.....	17	0.70	1.25	1.40	0.63	0.60	0.48
2	0.80	1.50	.80	.90	.60	.....	18	.70	1.30	1.20	.62	.62	.46
3	.80	1.90	.85	.80	.62	.....	19	.70	1.20	1.10	.68	.60	.45
4	.85	1.60	.85	.95	.66	.....	20	.75	.....	1.00	.65	.60	.....
5	1.00	1.30	.80	.90	.66	.....	21	.70	.....	.90	.68	.60	.....
6	1.05	1.20	.85	.80	.64	.....	22	.70	.....	.90	.70	.58	.....
7	1.05	1.30	.80	.70	.62	.....	23	.85	.....	.85	.68	.58	.....
8	1.10	1.30	.85	.90	.60	0.52	24	1.20	.....	.90	.62	.58	.....
9	1.00	1.70	.80	.90	.62	.54	25	1.30	.....	.90	.60	.58	.....
10	.90	1.70	.80	.75	.64	.52	26	1.20	.....	.80	.60	.58	.....
11	.80	1.45	.80	.70	.64	.50	27	1.10	.80	.80	.60	.58	.....
12	.90	1.45	.75	.68	.64	.48	28	1.10	.80	.75	.58	.58	.....
13	.90	1.30	.70	.65	.66	.48	29	1.30	.80	.75	.58	.60	.....
14	.80	1.30	.75	.65	.64	.48	30	1.70	.85	.70	.56	.62	.....
15	.70	1.25	1.20	.65	.60	.48	31	1.70	.....	1.15	.56	.....	.....
16	.70	1.25	1.50	.65	.60	.48							

Laramie River at Woods Landing, Wyoming.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	1.60	2.40	1.20	0.60	1.00	1.00
2	.....	1.55	2.28	1.10	.80	.90	1.00
3	.....	1.55	2.15	1.10	.80	.88	1.05
4	.....	1.60	2.30	1.00	.80	.80	1.00
5	.....	1.65	2.30	1.00	.80	.75	1.05
6	.....	1.95	2.05	.90	.80	.70	1.00
7	.....	2.15	1.95	.80	.70	.80	1.05
8	.....	2.25	1.85	.80	.70	.80	1.00
9	.....	2.00	1.85	.80	.75	.90	1.00
10	.....	2.00	1.90	.70	.70	1.15	1.00
11	.....	2.05	2.20	.70	.70	1.25	1.00
12	0.95	1.90	1.90	.70	.60	1.20	1.00
13	.80	1.75	1.70	.80	.60	1.05	1.00
14	1.05	1.70	1.90	.95	.60	.95	1.00
15	1.00	1.65	1.95	1.05	.60	.80	1.00
16	1.00	1.60	1.85	.85	.60	.85	.....
17	.90	1.60	1.70	1.30	.75	.85	.....
18	.80	1.70	1.65	1.15	.85	1.00	.....
19	.75	1.85	1.60	1.15	1.00	1.00	.....
20	.85	1.75	1.55	.95	1.30	1.00	.....
21	.95	1.75	1.50	.95	1.30	1.00	.....
22	1.25	1.75	1.45	.85	1.48	1.05	.....
23	1.30	1.83	1.50	1.25	1.35	1.10	.....
24	1.40	1.97	1.35	1.40	1.02	1.15	.....
25	1.60	2.02	1.35	1.30	.90	1.00	.....
26	1.75	2.15	1.35	1.40	.85	1.15	.....
27	1.85	2.00	1.30	1.40	.80	1.30	.....
28	2.05	2.10	1.20	1.25	.80	1.15	.....
29	1.65	2.10	1.20	1.00	.95	1.15	.....
30	1.75	3.25	1.20	.90	1.15	1.05	.....
31	.....	2.85	.....	.80	1.15	.....	.....

Laramie River at Uva, Wyoming.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	1.40	2.90	0.90	0.70	0.80	0.90
2	.....	1.60	4.00	.80	.70	.80	.82
3	.....	2.30	4.60	1.00	.70	.72	.82
4	.....	2.30	3.80	.90	.80	.72	.82
5	.....	2.10	3.00	.85	.80	.72	.80
6	1.80	2.00	2.70	.80	.70	.72	.80
7	1.80	2.00	2.70	.80	.70	.72	.80
8	1.75	2.10	2.80	.80	.60	.72	.80
9	1.75	2.10	2.50	.75	.70	.70	.80
10	1.60	2.30	2.30	.70	.70	.70	.80
11	1.60	2.40	2.00	.70	.80	.70	.80
12	1.50	2.40	1.50	.70	.80	.70	.80
13	1.50	2.50	1.40	.70	.70	.72	.80
14	1.60	2.50	1.40	.70	.90	.72	.80
15	1.70	2.40	1.30	.70	1.00	.72	.80
16	1.80	2.40	1.30	.80	1.00	.80	.....
17	1.70	2.20	1.20	.80	1.20	.80	.....
18	1.70	2.00	1.20	2.00	1.40	.82	.....
19	1.40	1.90	1.10	1.80	3.20	.82	.....
20	1.90	1.90	1.00	1.70	3.00	.82	.....
21	1.80	1.60	1.00	1.40	1.70	.82	.....
22	1.80	1.40	1.10	1.40	1.20	.90	.....
23	1.70	1.40	1.00	1.20	1.00	.90	.....
24	1.70	1.60	1.10	1.10	1.00	.90	.....
25	1.80	1.70	1.20	1.00	.90	.82	.....
26	1.30	1.70	1.10	1.00	.90	.82	.....
27	1.70	1.60	1.00	1.00	.90	.80	.....
28	1.70	1.50	1.00	1.00	.82	.80	.....
29	2.00	1.50	1.00	.90	.82	.80	.....
30	1.40	1.70	.90	.90	.80	.90	.....
31	.....	1.90	.....	.80	.80	.....	.....

North Platte River at Orin, Wyoming.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Dec.
1	.....	4.67	5.70	2.13	1.68	1.20	1.17	.....
2	.....	4.45	5.97	2.03	.....	1.20	1.32	2.30
3	.....	.....	6.07	2.00	1.68	1.27	1.37	.....
4	.....	4.05	5.85	2.00	1.58	1.30	.....	.....
5	.....	4.00	5.45	.....	1.48	1.40	1.30	.....
6	.....	4.00	5.00	1.75	1.38	.....	1.27	.....
7	.....	4.17	.....	1.62	1.28	1.17	1.22	.....
8	.....	4.37	4.80	1.52	1.18	1.07	1.17	.....
9	.....	4.62	4.68	1.48	.....	1.17	1.12	1.90
10	.....	.....	4.45	1.40	1.13	1.20	1.10	.....
11	.....	5.02	4.25	1.25	.98	1.07	.....	.....
12	.....	4.86	4.08	.....	.95	.97	1.15	1.90
13	2.68	4.82	4.25	1.13	.90	.....	1.10	.....
14	3.10	4.87	.....	1.10	.90	1.23	1.10	.....
15	3.47	4.75	4.13	2.30	.83	1.30	1.10	.....
16	3.65	4.55	3.95	2.20	.....	1.35	.....	2.00
17	3.62	.....	3.75	1.78	1.05	1.42	.....	.....
18	3.45	4.05	3.55	1.65	.80	1.37	.....	.....
19	.....	3.87	3.63	.....	.90	1.27	.....	2.10
20	3.05	3.70	3.73	2.45	1.10	.....	.....	.....
21	3.00	3.50	.....	2.35	.78	1.17	.....	.....
22	2.92	3.37	3.93	2.10	.85	1.07	.....	.....
23	3.10	3.35	3.70	2.08	.....	.97	.....	.....
24	3.35	.....	3.33	1.85	.87	.95	.....	.....
25	3.60	3.42	3.05	1.73	1.95	.90	.....	.....
26	.....	3.75	2.85	.....	1.67	.90	.....	1.80
27	4.05	4.22	2.65	1.63	1.45	.....	.....	.....
28	4.40	4.60	.....	1.53	1.37	1.02	.....	.....
29	4.55	4.70	2.35	1.50	1.42	1.07	.....	.....
30	4.62	4.87	2.23	1.50	.....	1.10	.....	.....
31	.....	.....	.....	1.50	1.27	.....	.....	.....

North Platte River at North Platte, Nebraska.

Day.	Jan.	Feb.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.50	2.85	.....	2.70	2.75	2.55	2.20	1.50	1.90	2.45	2.40
2	2.50	2.90	.....	2.75	2.90	2.55	2.15	1.75	1.80	2.50	2.40
3	2.50	2.80	.....	2.65	2.75	2.45	2.25	1.65	1.75	2.35	2.40
4	2.50	2.80	.....	2.85	2.55	2.35	2.30	1.65	1.70	2.20	2.30
5	2.60	2.65	.....	2.95	3.85	2.25	2.05	1.60	1.75	2.15	2.30
6	2.60	2.50	.....	3.15	4.00	2.20	2.15	1.60	1.70	1.90	2.30
7	2.60	2.45	.....	3.05	3.85	2.15	2.25	1.50	1.85	1.80	2.40
8	2.60	2.05	.....	3.15	3.70	2.00	2.05	1.50	1.90	1.70	2.45
9	2.65	2.00	.....	3.00	3.55	2.00	1.80	1.60	1.85	1.85	2.55
10	2.75	2.05	2.30	2.90	3.45	1.90	1.90	1.70	1.90	1.95	2.65
11	2.80	1.95	2.45	2.90	3.35	1.80	1.70	1.80	1.80	2.05	2.65
12	2.70	2.45	2.65	2.85	3.35	1.60	1.60	1.80	1.85	2.10	2.75
13	2.70	2.75	2.80	2.95	3.35	1.50	1.60	1.90	1.85	2.20	2.75
14	2.70	2.60	2.65	3.05	3.20	1.35	1.50	2.00	1.85	2.10	2.75
15	2.70	2.35	2.55	3.25	3.05	1.10	1.45	2.00	1.85	2.15	2.75
16	2.70	2.35	2.50	3.05	2.90	1.15	1.35	1.90	1.90	2.05	2.65
17	2.75	2.25	2.60	3.05	2.85	1.05	1.45	1.80	1.90	2.25	2.70
18	2.70	2.15	2.60	3.10	2.85	1.00	1.65	1.85	1.80	2.25	2.55
19	2.75	2.25	2.50	3.00	3.00	1.15	1.80	1.90	1.80	2.35	2.50
20	2.75	2.45	2.55	3.05	2.90	1.25	1.85	1.85	1.80	1.90	2.55
21	2.80	2.35	2.70	3.05	2.85	1.50	2.00	1.85	1.80	2.00	2.55
22	2.80	2.40	2.55	3.00	2.80	1.85	1.90	1.90	1.90	1.85	2.50
23	2.80	2.40	2.65	2.90	2.70	2.20	1.80	1.80	2.00	1.95	2.60
24	2.80	2.45	2.55	2.90	2.80	2.45	1.90	1.85	1.90	2.15	2.65
25	2.85	2.35	2.70	2.85	2.95	2.05	1.75	1.90	1.90	2.25	2.75
26	2.90	2.30	2.65	2.80	2.85	1.95	1.60	2.00	1.90	2.30	2.75
27	2.90	2.35	2.55	2.70	2.80	1.85	1.50	2.00	1.90	2.40	2.75
28	2.90	2.30	2.55	2.70	2.80	1.70	1.60	2.05	1.80	2.40	2.70
29	2.90	2.40	2.65	2.55	2.90	2.00	1.55	2.05	1.95	2.40	2.85
30	2.90	.....	2.65	2.55	2.55	1.95	1.50	2.00	1.95	2.40	2.85
31	2.85	.....	.....	2.60	.....	2.15	1.60	.....	2.25	.....	2.85

South Platte River at Deansbury, Colorado.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.93	2.96	3.30	4.39	2.70	2.78	0.98	1.39	1.80	1.46	1.36	0.80
2	2.95	3.02	3.15	4.24	2.68	2.78	.93	1.35	1.80	1.45	1.20	.78
3	2.97	3.14	3.09	4.12	2.64	2.74	.90	1.32	1.68	1.42	1.20	1.70
4	2.97	3.14	3.45	3.85	3.05	2.54	.88	1.23	1.90	1.45	1.16	a3.48
5	3.00	3.11	3.20	3.86	2.91	2.35	.96	1.18	1.74	1.42	1.07	3.27
6	3.10	3.12	3.23	4.68	3.30	2.24	.90	1.17	1.27	1.40	1.10	3.06
7	3.35	3.12	3.31	5.09	3.15	2.11	.95	1.12	1.30	1.38	.87	2.96
8	3.28	3.17	3.11	5.46	3.25	2.00	.99	1.02	1.25	1.32	.86	2.90
9	3.24	3.15	3.30	5.73	2.85	1.90	1.03	.93	1.23	1.33	1.11	3.00
10	3.40	3.18	3.26	5.36	2.65	1.80	.92	.83	1.55	1.42	1.20	2.90
11	3.12	3.19	3.35	5.35	2.52	1.68	.82	.77	1.83	1.42	1.00	2.81
12	3.05	3.20	3.31	5.53	2.33	1.60	.78	.74	1.74	1.41	.88	2.80
13	3.03	3.17	3.39	5.08	2.30	1.50	.73	.71	1.63	1.42	.97	2.80
14	2.95	3.22	3.33	5.47	2.44	1.45	.70	.73	1.54	1.39	1.22	2.80
15	2.91	3.17	3.16	6.00	2.28	1.44	.76	.74	1.43	1.37	1.19	2.76
16	2.90	3.26	3.38	6.47	2.30	1.40	1.32	.97	1.34	1.31	1.17	2.97
17	2.96	3.22	3.44	6.21	2.31	1.34	1.77	.96	1.30	1.29	1.18	2.90
18	3.00	3.22	3.14	5.72	2.43	1.30	1.72	1.79	1.37	1.26	1.18	2.71
19	3.00	3.26	3.45	5.36	2.41	1.24	1.92	1.73	1.54	1.33	1.15	2.76
20	3.05	3.28	3.67	5.41	2.24	1.24	2.09	1.68	1.71	1.37	1.17	2.81
21	3.05	3.34	3.80	5.39	2.15	1.27	2.21	1.34	1.80	1.27	1.16	2.77
22	3.08	3.33	3.87	5.64	2.12	1.29	2.11	1.42	1.75	1.28	1.07	2.73
23	3.02	3.31	3.97	5.89	2.20	1.25	1.92	1.72	1.66	1.40	1.07	2.72
24	3.01	3.26	4.26	5.97	2.40	1.18	1.62	1.39	1.57	1.37	1.19	2.69
25	2.95	3.34	4.75	6.79	2.43	1.15	2.14	1.31	1.56	1.38	1.10	2.67
26	3.02	3.41	5.81	a3.42	2.40	1.10	2.40	1.19	1.50	1.45	.92	2.69
27	2.94	3.42	6.52	3.59	2.46	1.10	2.35	1.08	1.50	1.43	.78	2.80
28	2.97	3.40	6.15	3.63	2.50	1.03	2.17	1.03	1.51	1.42	.80	2.72
29	3.00	3.23	5.86	3.18	2.49	1.03	1.81	1.07	1.55	1.41	.79	2.73
30	3.00	.....	5.30	3.02	2.58	1.03	1.60	1.17	1.50	1.31	.81	2.77
31	2.97	.....	5.06	.....	2.71	.....	1.54	1.40	.....	1.30	.....	2.76

a January 1 to April 25, station No. 1; April 26 to December 3, station No. 2; December 4 to 31, station No. 1.

South Platte River at Denver, Colorado.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.45	3.55	4.00	4.45	5.55	5.20	4.65	4.35	5.10	4.90	4.65	4.60
2	3.50	3.50	3.95	4.50	5.35	5.30	4.60	4.30	5.20	5.00	4.70	4.70
3	3.55	4.20	4.15	4.65	5.10	5.05	4.10	4.60	5.15	5.00	4.65	4.70
4	3.50	3.85	4.05	4.55	5.10	5.00	(a)	4.50	4.95	4.60	4.70	4.65
5	3.50	3.70	4.00	4.50	5.20	4.95	(a)	4.30	4.85	4.50	4.65	4.65
6	3.45	3.85	3.95	4.45	5.10	4.90	(a)	4.35	4.85	4.45	4.70	4.65
7	3.40	3.80	3.95	4.60	5.00	4.90	(a)	4.30	4.90	4.55	4.65	4.80
8	3.35	3.75	4.15	4.55	5.05	4.90	4.10	4.25	4.80	4.50	4.70	4.90
9	3.30	3.70	4.25	4.70	4.95	4.75	4.20	4.20	4.85	4.45	4.73	4.90
10	3.60	3.85	4.15	4.55	4.70	4.65	4.25	4.30	5.05	4.35	4.80	4.90
11	3.75	3.35	4.15	4.45	4.75	4.50	4.10	4.25	5.05	4.30	4.75	4.85
12	3.80	3.15	4.15	4.50	4.45	4.55	4.00	4.30	5.10	4.40	4.85	4.80
13	3.85	4.00	4.20	4.65	4.35	4.60	4.00	4.20	5.05	4.45	4.90	4.85
14	3.70	3.90	4.05	4.90	4.65	4.00	4.30	4.25	5.00	5.10	4.85	4.90
15	3.70	3.75	4.15	4.85	4.60	4.40	4.25	4.05	5.05	5.00	4.80	4.80
16	3.65	3.90	4.25	5.05	5.00	4.45	4.45	4.00	5.00	4.85	4.70	4.80
17	3.75	4.00	4.15	5.10	4.60	4.25	4.40	4.30	5.00	4.80	4.65	4.75
18	3.85	4.05	4.00	4.95	4.85	4.05	4.70	4.35	5.05	4.90	4.70	4.80
19	3.60	4.10	4.15	5.00	4.80	4.10	4.00	4.50	5.15	4.95	4.70	4.75
20	3.70	4.05	4.20	4.90	4.75	4.10	4.30	4.50	5.00	5.10	4.75	4.85
21	3.95	3.95	4.10	4.85	4.60	4.10	4.45	(b)	4.95	5.10	4.80	4.80
22	3.80	3.95	4.25	4.95	4.40	4.10	4.50	(b)	5.00	5.15	4.80	4.75
23	3.70	4.00	4.50	5.05	4.40	4.15	4.45	(b)	4.90	5.20	4.80	4.80
24	3.75	4.05	4.55	5.00	4.40	4.20	4.45	(b)	4.80	5.10	4.90	4.80
25	3.75	4.00	4.70	5.10	4.95	4.50	5.50	(b)	5.00	5.05	4.90	4.75
26	3.85	4.10	4.85	5.25	4.85	4.55	5.05	4.80	5.05	5.00	4.90	4.80
27	3.70	4.05	4.75	5.70	4.80	4.50	4.95	4.85	5.10	4.90	(c)	4.70
28	3.75	4.00	4.70	5.65	4.85	4.45	4.80	4.85	5.10	5.00	(c)	4.75
29	3.90	4.05	4.75	5.75	4.95	4.65	4.90	4.80	4.95	4.90	(c)	4.80
30	4.00	.....	4.65	5.60	4.85	4.65	4.85	4.85	5.00	4.70	(c)	4.65
31	3.80	.....	4.55	.....	5.00	.....	4.65	5.00	.....	4.65	.....	4.60

a July 4 to 7 water below gage. *b* September 21 to 25 sand in front of gage. *c* Frozen.

South Platte River at Orchard, Colorado, for 1895–96.

Day.	1895.		1896.				
	Nov.	Dec.	Jan.	Feb. *a*	Mar.	Apr.	Dec.
1	.....	4.15	3.85	4.15	3.70	3.70	4.26
2	.....	4.10	3.85	.....	3.70	3.70	4.25
3	.....	4.10	3.90	.....	3.70	3.75	4.45
4	.....	4.10	3.95	.....	3.75	4.00	4.60
5	.....	4.10	4.00	.....	3.80	.....	4.65
6	.....	4.10	4.00	.....	3.85	.....	4.65
7	.....	4.10	4.05	.....	3.90	.....	4.65
8	.....	4.05	4.10	.....	3.90	.....	4.65
9	.....	4.00	4.10	.....	3.90	.....	4.50
10	.....	4.00	4.00	.....	3.85	.....	4.45
11	.....	4.00	4.00	.....	3.80	.....	4.40
12	.....	4.00	3.95	.....	3.75	.....	4.60
13	.....	3.95	3.90	.....	3.70	.....	4.60
14	.....	3.95	3.80	.....	3.70	.....	4.80
15	.....	3.95	3.90	.....	3.70	.....	5.00
16	.....	3.95	3.95	3.90	3.70	.....	5.20
17	.....	3.95	4.00	3.85	3.70	.....	4.80
18	.....	3.90	4.00	3.85	3.75	.....	4.30
19	.....	3.90	4.00	3.85	3.75	.....	4.00
20	.....	3.90	4.00	3.85	3.80	.....	3.85
21	.....	3.95	4.00	3.85	3.80	.....	3.80
22	4.00	3.95	4.00	3.85	3.80	.....	3.80
23	4.05	3.95	4.00	3.80	3.75	.....	3.80
24	4.05	3.90	4.00	3.80	3.70	.....	3.80
25	4.10	3.90	4.00	3.75	3.70	.....	3.80
26	4.10	3.90	4.00	3.75	3.75	.....	3.80
27	4.10	3.85	4.00	3.70	3.75	.....	3.75
28	4.10	3.80	4.00	3.70	3.80	.....	3.75
29	4.15	3.80	4.00	3.70	3.85	.....	3.75
30	4.15	3.85	4.10	.....	3.80	.....	3.75
31	.....	3.85	4.10	.....	3.70	.....	3.75

a February 2 to 15 observer away; no record.

Bear Creek at Morrison, Colorado.

Day.	Apr.	May.	June.	July.a	Aug. a	Sept.	Oct.
1	.....	0.92	1.00	0.70	.....	2.88	2.80
2	.....	.87	.95	.69	.....	2.83	2.75
3	.....	.97	.90	.78	.....	2.90	2.75
4	.....	1.02	.85	.70	.....	2.90	2.75
5	.....	.97	.83	.75	2.93	2.85	2.75
6	0.70	1.10	.85	.70	3.00	2.80	2.75
7	.80	1.07	.85	.78	3.00	2.83	2.75
8	.80	1.02	.80	.78	3.00	2.79	2.75
9	.68	.87	.78	.78	2.88	2.83	2.73
10	.75	.90	.75	.68	2.88	3.00	2.73
11	.73	.92	.75	.63	2.85	2.95	2.70
12	.77	.87	.71	.60	2.83	2.90	2.70
13	.80	.82	.72	.55	2.80	2.85	2.70
14	.92	.80	.71	.55	2.78	2.78	2.70
15	1.00	.85	.73	.58	2.75	2.75	2.70
16	.90	.82	.75	.80	2.75	2.75	2.70
17	.95	.92	.74	.95	2.78	2.75	2.70
18	.72	.92	.75	1.00	2.80	2.80	2.70
19	.75	.90	.75	1.03	2.83	2.98	2.70
20	.80	.87	.73	1.03	2.85	2.98	2.70
21	.97	.87	.73	.93	2.90	2.88	2.70
22	1.02	.92	.73	.90	2.98	2.88	2.70
23	1.07	.95	.70	1.03	2.98	2.83	2.70
24	1.10	1.07	.70	.88	2.88	2.80	2.78
25	1.15	1.05	.78	.....	2.80	2.80	2.78
26	1.17	1.02	.95	.....	2.80	2.80	2.75
27	1.22	.92	.80	.....	2.80	2.90	2.75
28	1.17	.95	.80	.....	2.78	2.85	2.78
29	1.11	.97	.75	.....	2.75	2.80	2.70
30	.95	1.02	.73	.....	2.88	2.80	2.70
31	.....	1.00	.....	.....	2.98	.....	2.65

a From July 25 to August 5 no record; rod washed away by flood.

South Boulder Creek at Marshall, Colorado.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	0.80	1.85	2.30	1.55	1.15	1.10	0.95
2	1.05	1.55	2.10	1.55	1.05	1.10	.95
3	.90	1.65	2.10	1.55	1.05	1.10	.85
4	.95	1.85	2.30	1.50	1.05	1.10	.80
5	.90	1.70	2.15	1.50	1.05	1.10	.80
6	.90	1.90	2.20	1.45	1.05	1.10	.80
7	1.05	1.95	2.00	1.45	1.05	1.05	.85
8	1.05	2.05	1.95	1.45	1.05	1.05	1.00
9	1.05	2.10	2.20	1.40	.95	1.05	1.00
10	1.05	2.10	2.15	1.40	.95	1.10	1.00
11	1.15	2.20	2.25	1.40	.95	1.10	1.00
12	1.15	1.95	2.15	1.35	.95	1.10	1.00
13	1.20	1.80	2.10	1.35	.95	1.10	.95
14	1.35	1.75	2.05	1.35	.95	1.10	.95
15	1.35	1.70	2.05	1.30	.95	1.05	.90
16	1.35	1.75	2.00	1.60	.95	1.05	.90
17	1.45	1.75	1.95	1.50	.95	1.10	.90
18	1.15	1.70	1.95	1.50	1.00	1.15	.90
19	1.20	1.65	1.95	1.50	1.40	1.15	.90
20	1.20	1.70	1.90	1.40	1.90	1.05	.85
21	1.40	1.65	1.90	1.30	1.45	1.05	.80
22	1.55	1.70	1.85	1.30	1.20	1.00	.80
23	1.60	1.85	1.85	1.30	1.30	1.00	.90
24	1.75	2.00	1.80	1.30	1.15	1.00	.90
25	1.70	2.00	1.75	1.30	1.10	1.00	.90
26	1.80	2.30	1.70	1.30	1.10	1.00	.90
27	1.90	2.35	1.65	1.30	1.10	1.00	.90
28	1.90	2.40	1.65	1.30	1.10	1.00	.80
29	1.80	2.45	1.65	1.25	1.10	1.00	.80
30	1.80	2.55	1.60	1.25	1.10	1.00	.80
31	.....	2.50	.....	1.20	1.10	.....	.80

Boulder Creek at Boulder, Colorado.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	0.20	1.10	2.05	1.30	0.98	1.08	0.65
2	.35	1.10	1.77	1.30	.95	1.00	.63
3	.22	1.15	1.90	1.30	.88	1.08	.60
4	.27	1.17	1.92	1.30	.83	1.03	.55
5	.25	1.25	1.97	1.35	.80	1.00	.50
6	.27	1.35	1.97	1.73	.80	.98	.50
7	.27	1.45	1.90	1.57	.78	.93	.45
8	.30	1.85	1.88	1.45	.73	.88	.43
9	.45	1.85	1.95	1.38	.69	.85	.45
10	.47	1.75	1.95	1.35	.65	.90	.45
11	.50	1.75	2.00	1.28	.65	.90	.53
12	.50	1.40	1.88	1.23	.65	.80	.60
13	.52	1.30	1.80	1.15	.63	.73	.58
14	.57	1.17	1.83	1.18	.60	.70	.55
15	.57	1.12	1.88	1.32	.60	.65	.50
16	.77	1.07	1.80	1.50	.65	.60	.50
17	.77	.95	1.75	1.45	.70	.63	.45
18	.77	1.07	1.65	1.38	1.23	.75	.45
19	.62	1.02	1.60	1.35	2.15	.90	.45
20	.75	1.00	1.55	1.25	1.05	.80	.43
21	.82	1.12	1.55	1.23	1.20	.80	.40
22	1.00	1.15	1.55	1.30	1.35	.75	.40
23	1.07	1.45	1.48	1.35	1.28	.78	.45
24	1.20	1.70	1.45	1.45	1.15	.80	.45
25	1.27	1.90	1.48	1.45	.98	.75	.40
26	1.45	1.95	1.43	1.40	.88	.80	.45
27	1.80	2.05	1.40	1.38	.88	.80	.45
28	1.85	2.15	1.38	1.33	.90	.75	.45
29	1.75	2.20	1.33	1.30	1.00	.70	.40
30	1.60	2.32	1.33	1.18	1.10	.70	.40
31	.....	2.15	.....	1.05	1.20	.....	.35

St. Vrain Creek at Lyons, Colorado.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	1.63	2.60	3.50	2.80	2.50	2.75	2.38
2	1.77	2.65	3.45	2.85	2.50	2.63	2.38
3	1.85	2.45	3.50	2.85	2.50	2.75	2.38
4	1.90	2.55	3.65	2.80	2.50	2.55	2.38
5	1.85	2.55	3.35	2.80	2.48	2.58	2.38
6	2.00	2.80	3.60	2.80	2.48	2.55	2.30
7	2.05	2.95	3.30	2.80	2.48	2.55	2.30
8	2.20	3.15	3.30	2.80	2.40	2.30	2.28
9	2.10	3.20	3.70	2.70	2.38	2.35	2.30
10	2.10	3.10	3.70	2.70	2.30	2.45	2.28
11	2.15	3.10	3.70	2.75	2.30	2.35	2.30
12	2.20	2.80	3.40	2.65	2.28	2.80	2.25
13	2.10	2.65	3.35	2.65	2.23	2.55	2.25
14	2.15	2.50	3.35	2.65	2.20	2.45	2.28
15	2.30	2.50	3.35	2.85	2.20	2.43	2.30
16	2.30	2.50	3.35	3.10	2.25	2.35	2.28
17	2.15	2.50	3.30	3.05	2.38	2.38	2.25
18	2.10	2.50	3.30	2.95	3.40	2.45	2.25
19	2.00	2.60	3.10	2.80	3.10	2.58	2.23
20	2.35	2.50	3.20	2.75	2.70	2.50	2.23
21	2.55	2.50	3.15	2.65	2.80	2.53	2.28
22	2.55	2.55	3.15	2.70	3.50	2.45	1.93
23	2.60	2.85	3.10	2.95	3.35	3.50	1.75
24	2.55	3.10	2.95	3.30	2.95	2.58	1.85
25	2.60	3.40	3.25	3.15	2.75	2.45	1.75
26	2.70	3.40	2.85	3.05	2.70	2.43	1.63
27	2.95	3.35	2.80	2.85	2.60	2.40	2.20
28	2.90	3.55	2.80	2.70	2.55	2.43	2.23
29	2.45	3.85	2.85	2.60	2.50	2.38	2.20
30	2.65	4.40	2.75	2.60	2.65	2.38	2.28
31	.....	3.85	.....	2.53	2.75	.....	2.20

Big Thompson Creek at Arkins, Colorado.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	0.10	1.35	1.20	1.20	1.25	1.05
2	.....	.50	1.65	1.25	1.10	1.00	.95
3	.....	.80	1.80	1.25	1.05	1.00	.95
4	.....	.85	1.80	1.20	1.00	1.00	.90
5	.....	.90	1.65	1.20	.95	1.00	.90
6	.....	1.00	1.70	1.20	.90	.85	.85
7	.....	1.10	1.50	1.15	.75	.80	.90
8	.....	1.05	1.55	1.55	.75	1.00	.80
9	.....	1.20	1.45	1.20	.75	.95	.90
10	.....	1.25	1.55	1.15	.70	.90	.85
11	.....	1.35	1.65	1.25	.75	1.00	.90
12	.....	1.15	1.45	1.20	.75	.95	.85
13	.....	1.10	1.55	1.10	.75	.85	.85
14	.....	.95	1.65	1.15	.75	.90	.85
15	.....	.90	1.55	1.20	.65	.90	.90
16	.....	.85	1.55	1.70	.80	.80	.85
17	.....	.85	1.55	1.55	.70	1.00	.80
18	.....	.85	1.55	1.25	.75	.95	.75
19	.....	.90	1.30	1.45	.85	.95	.70
20	.....	.95	1.35	1.35	.95	1.00	.65
21	.....	1.00	1.40	1.30	1.50	1.05	.60
22	.....	1.10	1.35	1.20	1.75	1.00	.60
23	.....	1.30	1.40	1.35	1.65	1.00	.65
24	.....	1.70	1.30	1.70	1.55	1.05	.65
25	.....	1.75	1.25	1.45	1.45	1.00	.60
26	.....	1.75	1.25	1.45	1.35	1.05	.40
27	.....	1.75	1.20	1.45	1.25	1.00	.40
28	0.80	1.65	1.20	1.40	1.15	1.05	.40
29	.60	1.80	1.25	1.40	1.00	1.00	.40
30	.25	2.30	1.20	1.30	1.10	1.00	.40
31	.....	1.80	.....	1.25	1.30	.....	.40

Frenchman River at Palisade, Nebraska.

[River heights on main and supplementary gages. Gage heights are all referred to original zero of main gage.]

Date.	South gage.	Main gage.	North gage.	Differences in heights.		
				South gage, main gage.	Main gage, north gage.	South gage, north gage.
1896.						
June 18	1.85	1.66	1.11	0.19	0.55	0.74
June 23	2.11	2.05	1.35	.06	.70	.76
June 25	2.10	1.93	1.35	.17	.58	.75
June 27	2.06	1.87	1.34	.19	.53	.72
July 1	2.14	1.96	1.40	.18	.56	.74
July 3	2.13	1.94	1.39	.19	.55	.74
July 5	2.13	1.93	1.38	.20	.55	.74
July 7	2.03	1.87	1.27	.16	.60	.76
July 9	1.97	1.75	1.15	.22	.60	.82
July 11	1.94	1.73	1.17	.21	.56	.77
July 14	1.96	1.74	1.19	.22	.55	.77
July 16	1.99	2.05	1.21	—.06	.84	.78
July 18	1.91	1.75	1.13	+.16	.62	.78
July 21	1.89	1.74	1.11	.15	.63	.78
July 23	1.89	1.74	1.13	.15	.61	.76
July 25	1.87	1.75	1.12	.12	.63	.75
July 28	1.89	1.75	1.13	.14	.62	.76
July 30	1.89	1.74	1.15	.15	.59	.74
Aug. 1	1.89	1.72	1.14	.17	.58	.75
Aug. 4	1.89	1.70	1.13	.19	.57	.76
Aug. 6	1.89	1.69	1.13	.20	.56	.76
Aug. 8	1.88	1.69	1.12	.19	.57	.76
Aug. 25	1.87	1.79	1.08	.08	.71	.79
Aug. 28	1.87	1.74	1.06	.13	.68	.81
Aug. 31	1.87	1.75	1.09	.12	.66	.78
Sept. 4	1.83	1.79	1.17	.04	.62	.66
Sept. 9	1.89	1.74	1.13	.15	.61	.76
Sept. 12	1.84	1.75	1.10	.09	.65	.74
Sept. 14	1.99	1.79	1.17	.20	.62	.82
Sept. 20	1.98	1.77	1.19	.21	.58	.79
Sept. 29	2.00	1.79	1.23	.21	.56	.77

Republican River at Junction City, Kansas.

Day.	Jan.	Feb.	Mar.[a]	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.55	3.65	*3.50*	3.50	4.45	4.90	3.55	4.00	3.10	2.80	4.65	3.70
2	3.40	3.95	*3.50*	3.50	4.30	6.30	3.35	3.80	3.00	2.80	4.25	3.85
3	3.30	4.05	*3.50*	3.50	4.25	7.20	3.30	3.60	2.95	2.80	3.90	3.80
4	3.05	3.90	*3.50*	3.50	5.25	6.20	3.40	3.45	2.85	2.75	3.55	3.75
5	3.10	3.80	*3.50*	3.50	5.95	6.20	3.35	3.60	2.80	2.80	3.40	3.95
6	3.05	3.85	*3.50*	3.50	6.20	4.95	6.10	3.60	2.80	2.75	3.30	3.80
7	2.90	4.05	*3.50*	3.50	6.45	4.95	5.80	3.45	2.70	2.70	3.20	3.60
8	3.10	4.00	*3.50*	3.50	6.45	4.55	5.70	3.35	2.65	2.70	3.10	3.50
9	3.05	3.80	*3.50*	3.65	5.10	4.65	5.40	3.25	2.60	2.70	3.10	3.50
10	3.35	3.75	*3.50*	3.45	4.50	4.55	5.00	3.15	2.75	2.70	3.10	3.50
11	3.30	3.85	*3.50*	3.40	4.20	4.30	4.85	3.00	2.75	2.70	3.20	3.50
12	3.30	3.80	*3.50*	3.50	4.10	4.15	4.95	3.55	2.60	2.70	3.20	3.50
13	3.35	3.75	*3.50*	3.45	4.40	3.95	4.85	3.70	2.60	2.75	3.20	3.50
14	3.30	3.70	*3.50*	3.50	5.40	3.85	4.55	3.65	5.00	2.80	3.20	3.55
15	3.35	3.65	*3.50*	4.90	5.70	3.85	4.40	3.20	3.65	2.80	3.20	3.60
16	3.50	3.60	*3.50*	6.50	5.90	3.85	4.20	3.00	3.50	2.80	3.30	3.60
17	3.30	3.60	*3.50*	6.75	5.60	3.75	4.20	3.00	3.70	2.70	3.30	3.65
18	3.20	3.60	*3.50*	5.65	5.00	3.60	10.97	3.00	3.75	2.70	3.30	3.50
19	3.10	3.55	*3.50*	5.10	6.50	3.55	8.80	3.20	4.70	2.75	3.35	3.30
20	3.05	3.55	*3.50*	4.55	7.00	3.45	6.50	4.50	5.40	2.70	3.35	3.45
21	3.05	3.55	*3.50*	4.25	6.10	3.70	5.15	4.95	4.35	2.70	3.30	3.50
22	3.20	3.60	*3.50*	4.10	5.30	3.55	5.65	5.35	3.65	2.70	3.25	3.60
23	3.40	3.60	*3.50*	4.10	4.75	3.55	5.10	4.70	3.35	2.70	3.05	3.80
24	3.30	3.55	*3.50*	6.20	4.40	3.85	4.35	4.35	3.15	2.70	3.10	3.70
25	3.20	3.55	*3.50*	5.90	4.25	4.05	4.10	4.05	3.05	2.70	3.00	3.50
26	3.15	3.50	*3.50*	5.30	4.05	3.65	3.80	3.80	3.00	2.70	3.50	3.50
27	3.05	3.55	*3.50*	5.40	3.85	4.15	3.65	3.75	2.90	2.75	3.50	3.50
28	3.20	3.50	*3.50*	4.95	3.80	3.90	3.60	3.95	2.80	2.50	3.40	3.50
29	3.30	3.50	*3.50*	4.75	3.75	3.85	3.55	3.55	2.80	3.00	3.30	3.70
30	3.40	.....	*3.50*	4.85	4.05	3.45	3.45	3.35	2.80	4.65	3.50	3.65
31	3.40	.....	*3.50*	.....	6.40	.....	3.45	3.25	.....	5.25	.....	3.75

[a] Figures in italics are estimated.

Solomon River at Beloit, Kansas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.70	2.90	2.00	2.70	4.05	7.13	4.55	4.95	3.75	3.20	3.30	3.10
2	2.70	2.82	3.00	2.35	4.20	9.50	4.25	4.75	3.80	3.60	2.90	3.00
3	2.30	2.92	2.75	2.35	3.80	7.20	4.50	4.45	3.50	3.20	2.70	3.10
4	2.70	2.92	2.80	2.40	3.65	5.90	4.43	4.05	3.40	2.40	2.90	3.10
5	1.75	2.92	2.25	2.30	3.65	4.85	4.80	3.95	3.40	3.10	2.85	3.10
6	2.70	2.90	2.70	2.75	3.55	4.75	6.80	3.85	2.55	2.60	2.80	2.30
7	2.30	2.92	2.70	2.80	3.50	4.90	6.00	4.10	3.25	3.00	3.00	3.10
8	2.70	2.95	2.25	2.75	3.30	5.55	4.50	4.60	3.40	2.95	2.20	3.10
9	2.70	2.42	2.90	2.60	3.20	4.65	4.25	4.25	2.85	3.15	3.00	3.10
10	2.70	2.92	2.70	2.60	3.20	4.25	4.15	4.20	3.40	3.05	3.00	3.10
11	2.30	3.00	2.80	2.00	3.40	4.15	5.20	4.00	3.45	2.15	3.05	3.10
12	1.90	2.92	2.75	4.85	3.25	4.10	4.70	4.15	3.40	2.80	3.00	3.30
13	2.70	2.55	2.75	15.50	3.30	4.05	4.25	4.00	2.85	2.65	3.00	2.65
14	2.30	2.95	2.75	11.60	4.60	3.80	4.00	3.70	3.75	2.60	3.00	3.30
15	2.30	2.92	2.25	11.90	4.80	3.85	3.85	3.60	5.25	2.60	2.20	3.25
16	2.70	2.37	2.65	5.80	4.70	3.60	3.65	3.65	4.05	2.85	3.05	3.35
17	2.70	2.82	2.75	4.50	8.32	3.80	3.85	3.45	3.75	3.15	3.00	3.05
18	2.95	2.72	2.70	4.35	4.40	3.80	4.05	3.70	3.95	2.50	3.00	3.15
19	2.30	2.75	2.70	4.20	4.30	4.20	3.95	3.65	4.00	2.75	3.05	3.10
20	2.90	2.75	2.75	4.60	5.40	4.60	3.95	3.90	4.15	3.05	3.10	2.50
21	2.95	2.72	2.75	4.20	4.80	4.15	3.90	4.55	3.95	2.65	2.70	3.15
22	2.95	2.70	2.50	3.90	4.25	4.00	4.60	4.35	3.70	3.05	2.40	3.15
23	2.70	2.25	2.70	3.70	4.00	4.05	4.05	4.40	3.60	3.05	3.10	3.20
24	2.95	2.70	2.70	3.70	3.80	3.75	4.05	4.55	3.85	2.80	3.10	3.20
25	2.95	2.70	2.70	3.65	4.35	3.90	3.95	4.95	3.55	2.55	3.10	2.60
26	2.30	2.75	2.75	3.50	4.15	3.95	4.00	4.40	3.80	2.55	2.30	3.15
27	2.90	2.70	3.00	3.65	3.65	4.05	4.00	4.25	2.65	2.55	3.10	2.50
28	2.90	2.60	2.80	4.05	3.70	4.05	3.90	4.15	3.55	3.10	2.90	3.20
29	2.90	2.75	2.30	3.75	3.35	4.10	5.30	3.90	3.10	8.50	2.30	3.20
30	2.90	.....	2.75	3.75	3.30	5.90	16.75	3.65	2.75	5.10	3.05	3.20
31	2.87	.....	2.60	.....	3.70	.....	6.25	3.90	.....	3.75	.....	3.20

Saline River at Beverly, Kansas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.20	4.45	4.35	4.15	5.20	20.25	7.00	5.10	4.40	4.20	5.65	4.20
2	4.20	4.50	4.20	4.30	5.35	23.00	6.40	4.80	4.50	4.35	5.25	4.30
3	4.00	4.45	4.15	4.35	5.10	23.50	6.95	4.70	4.45	4.40	4.90	4.40
4	3.85	4.80	4.10	4.20	10.55	21.50	7.15	4.80	4.20	4.20	4.90	4.35
5	3.85	4.70	4.25	4.15	8.85	13.05	6.95	4.60	4.30	4.20	4.75	4.30
6	4.40	4.45	4.25	4.20	5.20	9.20	6.13	5.00	4.15	4.30	4.75	4.30
7	4.30	4.35	4.30	4.15	4.85	12.10	5.75	5.00	4.35	4.35	4.75	4.15
8	4.40	4.35	4.30	4.60	4.70	10.55	7.35	5.05	4.30	4.35	4.65	4.80
9	4.15	4.25	4.45	4.90	4.75	8.50	6.00	4.65	4.10	4.35	4.45	4.65
10	4.25	4.15	4.25	4.65	4.65	6.90	5.75	4.60	4.45	4.35	4.70	4.55
11	4.30	4.25	4.50	4.50	4.65	6.50	8.10	4.85	4.50	4.15	4.65	4.65
12	4.55	4.25	4.35	4.45	4.70	6.20	9.35	4.55	4.30	4.35	4.45	4.50
13	4.50	4.35	4.30	6.40	7.30	6.05	6.90	4.65	4.40	4.30	4.30	4.40
14	4.50	4.35	4.40	9.70	7.40	5.90	5.85	4.45	4.40	4.35	4.55	4.05
15	4.40	4.30	4.40	5.80	5.60	5.70	5.55	4.20	4.40	4.35	4.30	4.70
16	4.30	4.10	4.45	5.05	7.25	5.60	5.45	4.75	4.50	4.35	4.50	4.50
17	4.50	4.15	4.25	5.50	6.50	5.80	5.30	4.95	4.55	4.30	4.60	4.55
18	4.45	4.20	4.40	5.40	5.80	5.75	8.50	4.85	4.45	4.20	4.50	4.25
19	4.50	4.15	4.25	5.05	5.75	5.50	7.65	4.70	4.60	4.25	4.60	4.50
20	4.40	4.40	4.35	4.80	7.20	5.50	7.25	4.80	4.70	4.10	4.40	4.25
21	4.55	4.25	4.30	4.90	6.55	10.80	5.95	4.75	4.75	4.25	4.40	4.35
22	4.55	4.25	4.20	4.75	5.75	7.65	5.45	4.75	4.60	4.35	4.55	4.30
23	4.60	4.35	4.35	4.70	5.20	8.85	5.25	7.50	4.50	4.35	4.20	4.25
24	4.55	4.20	4.20	4.65	4.95	6.80	5.85	5.95	4.50	4.25	4.30	4.60
25	4.40	4.15	4.30	4.65	4.70	6.20	5.55	5.10	4.40	4.05	4.55	4.50
26	4.25	4.20	4.40	6.60	4.60	6.75	5.10	4.85	4.35	4.30	4.55	4.15
27	4.25	4.30	4.30	9.30	4.55	8.30	5.00	4.65	4.35	4.15	4.30	.....
28	4.20	4.40	4.25	7.35	4.45	8.20	4.95	4.70	4.40	4.40	4.35	.....
29	4.15	4.25	4.40	5.75	4.40	8.00	4.90	4.55	4.30	5.75	4.30	.....
30	4.20	.....	4.25	5.30	4.25	7.90	6.90	4.50	4.45	15.35	4.25	.....
31	4.40	.....	4.10	.....	13.00	.....	5.85	4.45	.....	7.10	.....	.....

Smoky Hill River at Ellsworth, Kansas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.50	1.40	1.30	1.20	1.72	1.85	2.63	2.05	1.68	1.45	1.95	1.33
2	1.50	1.50	1.27	1.20	1.67	1.75	2.45	1.90	1.60	1.43	1.85	1.30
3	1.42	1.50	1.35	1.20	1.65	1.62	2.25	1.78	1.58	1.40	1.88	1.30
4	1.42	1.50	1.27	1.20	1.70	1.55	2.20	1.68	1.53	1.40	1.78	1.30
5	1.35	1.50	1.30	1.20	1.62	1.90	2.13	1.65	1.48	1.43	1.70	1.28
6	1.32	1.50	1.30	1.20	1.60	1.95	2.03	1.78	1.45	1.35	1.63	1.28
7	1.27	1.40	1.30	1.20	1.52	4.05	4.30	1.88	1.43	1.35	1.53	1.30
8	1.42	1.30	1.30	2.10	1.50	7.10	2.10	1.75	1.40	1.30	1.50	1.25
9	1.42	1.35	1.30	1.42	1.47	3.75	2.00	1.65	1.40	1.30	1.50	1.23
10	1.35	1.47	1.30	1.27	1.50	2.75	1.93	1.58	1.50	1.40	1.45	1.25
11	1.35	1.40	1.27	1.20	1.45	2.45	3.50	1.50	1.48	1.35	1.43	1.25
12	1.32	1.40	1.27	1.55	1.47	2.15	2.90	1.55	1.40	1.33	1.40	1.25
13	1.42	1.40	1.22	2.30	1.85	2.05	2.50	1.58	1.45	1.30	1.40	1.25
14	1.35	1.40	1.37	2.25	1.72	1.95	2.23	1.63	1.43	1.28	1.35	1.20
15	1.32	1.40	1.37	1.85	1.67	1.85	2.03	1.68	1.40	1.25	1.35	1.20
16	1.32	1.40	1.27	1.97	1.62	1.83	2.00	1.60	1.40	1.23	1.35	1.20
17	1.27	1.35	1.32	2.37	1.55	1.80	1.98	1.50	1.40	1.20	1.30	1.23
18	1.27	1.35	1.32	3.00	1.50	1.83	2.90	1.50	1.45	1.20	1.30	1.13
19	1.30	1.35	1.25	2.10	1.50	1.85	3.60	1.55	1.90	1.20	1.20	1.35
20	1.35	1.32	1.30	1.97	1.50	1.73	2.65	1.50	1.68	1.20	1.20	1.25
21	1.32	1.32	1.30	1.97	1.50	4.30	2.35	1.50	1.60	1.20	1.28	1.20
22	1.35	1.35	1.30	1.90	1.47	2.30	2.08	3.00	1.63	1.20	1.15	1.20
23	1.32	1.35	1.30	1.92	1.60	2.10	2.15	2.40	1.68	1.28	1.23	1.20
24	1.40	1.30	1.30	1.87	1.47	2.65	2.15	1.85	1.70	1.28	1.25	1.20
25	1.45	1.30	1.27	4.30	1.40	2.50	2.00	1.95	1.70	1.25	1.25	1.20
26	1.37	1.30	1.30	2.80	1.40	2.35	1.93	2.43	1.68	1.28	1.33	1.25
27	1.52	1.30	1.30	2.10	1.35	2.45	1.88	2.28	1.58	1.30	1.35	1.25
28	1.42	1.30	1.27	2.00	1.30	3.85	2.00	2.05	1.53	1.30	1.30	1.20
29	1.40	1.30	1.20	1.85	1.30	3.30	1.93	1.93	1.50	2.63	1.25	1.20
30	1.40	.....	1.20	1.80	1.30	2.90	2.40	1.83	1.48	2.40	1.30	1.20
31	1.40	.....	1.20	.....	1.52	.....	2.20	1.73	.....	2.28	.....	1.20

Blue River at Manhattan, Kansas.

Day.	Jan.	Feb.	Apr.a	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.70	3.80	.....	5.60	20.55	11.15	9.75	4.80	4.70	10.50	5.00
2	3.60	3.80	.....	5.35	20.30	18.30	8.80	4.60	4.60	8.50	5.00
3	3.55	3.75	.....	5.75	13.85	22.25	7.10	4.85	4.55	7.90	4.80
4	3.70	3.75	.....	13.95	11.85	22.20	6.70	5.50	4.70	7.00	4.65
5	3.70	3.75	.....	16.75	8.80	19.00	6.00	5.20	4.85	6.40	4.00
6	3.80	3.80	.....	13.25	8.75	10.75	5.70	5.15	5.05	5.90	4.00
7	3.75	3.70	.....	9.50	8.25	8.15	7.60	4.95	4.90	5.40	4.25
8	3.75	3.85	.....	7.60	8.35	7.50	8.25	4.85	4.50	5.00	4.55
9	3.80	3.75	.....	6.20	14.50	7.75	7.35	5.05	4.25	5.00	4.60
10	3.85	3.75	.....	6.45	14.50	9.40	7.35	5.15	4.00	4.90	4.80
11	3.80	3.65	.....	6.10	12.30	9.25	5.85	5.00	4.30	4.80	4.90
12	3.70	3.65	.....	5.75	9.55	9.20	5.45	5.20	4.00	4.50	5.00
13	3.65	3.70	.....	5.65	7.20	9.35	5.60	5.15	3.90	4.40	5.00
14	3.50	3.55	.....	11.20	7.20	8.65	8.10	7.50	3.70	4.30	5.00
15	3.55	3.55	.....	13.65	6.35	7.75	10.75	9.75	3.60	4.20	4.80
16	3.60	3.60	5.50	12.30	5.95	6.40	9.70	8.15	3.70	4.00	4.80
17	3.65	3.65	7.20	11.50	5.60	6.25	7.80	6.65	3.30	4.00	4.70
18	3.60	3.65	9.95	11.00	5.20	9.15	6.95	6.15	3.20	3.80	4.70
19	3.55	3.60	11.05	11.45	5.00	13.90	10.15	10.50	3.15	3.80	4.70
20	3.50	3.70	10.20	14.40	4.90	12.70	15.85	10.25	3.00	3.50	4.50
21	3.75	3.65	8.35	13.25	4.30	12.00	10.25	7.60	3.00	3.50	4.30
22	3.60	3.40	7.20	11.35	4.05	10.75	7.75	6.15	3.00	3.50	4.00
23	3.60	3.45	6.55	10.35	5.10	9.35	5.95	5.85	3.00	3.80	4.00
24	3.30	3.55	6.05	11.05	5.75	7.25	6.75	6.10	3.05	3.80	3.80
25	3.45	3.65	5.70	10.05	5.45	5.60	8.40	5.40	3.00	3.90	3.70
26	3.65	3.60	5.35	9.00	9.20	5.20	6.90	5.05	3.10	4.85	3.50
27	3.75	3.60	5.35	8.35	12.60	5.40	5.75	5.00	3.00	5.60	3.00
28	3.80	3.45	5.20	7.65	10.70	5.10	5.45	4.95	2.80	5.40	3.00
29	3.75	.....	5.20	6.90	9.40	4.65	5.45	4.80	10.00	5.30	3.00
30	3.70	.....	5.25	6.40	8.25	6.70	5.10	4.70	12.75	5.20	3.65
31	3.80	.....	.....	14.15	.....	11.60	4.95	.....	12.25	.....	4.00

a Observations discontinued from March 1 to April 15; observer moved away.

Kansas River at Lecompton, Kansas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	0.82	0.72	0.58	0.73	2.37	8.50	3.25	3.08	2.21	1.25	4.46
2	.76	.70	.73	.71	2.37	9.33	3.50	3.65	2.04	1.21	3.88
3	.85	.72	.75	.67	2.35	8.67	5.96	3.21	1.88	1.17	3.50
4	.65	.77	.60	.67	2.42	7.50	8.00	2.85	1.58	1.21	3.15
5	.42	.85	.83	.65	4.92	6.17	8.25	2.92	1.46	1.08	3.13
6	.49	.93	.79	.67	6.54	7.13	7.58	2.92	1.25	1.15	2.92
7	.57	.93	.67	.79	5.42	6.92	5.13	2.50	1.17	1.04	2.38
8	.56	.88	.38	.77	4.33	6.42	3.88	2.85	1.17	.98	.....
9	.63	.95	.42	.83	3.83	5.92	3.58	2.94	1.17	.92	.....
10	.65	.92	.42	.75	3.60	6.67	3.42	2.71	1.13	.95	.....
11	.77	.88	.46	.75	3.04	6.79	3.54	2.25	1.08	.97	.....
12	.88	.79	.48	1.08	2.58	5.58	3.67	2.17	1.19	1.00	.....
13	.87	.75	.48	1.25	2.42	4.92	3.75	2.08	1.48	1.03	.....
14	.94	.74	.50	1.02	3.08	4.21	3.38	1.96	1.38	1.00	.....
15	.85	.82	.58	.94	3.88	3.54	2.96	1.92	2.92	.95	.....
16	.66	.75	.50	.92	8.46	3.08	2.63	3.04	4.71	.90	.....
17	.60	.72	.42	.92	8.13	2.79	2.40	3.21	3.96	.92	.....
18	.54	.73	.65	1.50	6.58	2.58	3.46	4.46	2.37	.86	.....
19	.53	.69	.75	4.71	5.63	2.38	10.25	4.25	2.25	.85	.....
20	.58	.70	.50	5.00	8.67	2.21	11.63	7.13	2.08	.83	.....
21	.53	.67	.50	4.67	8.92	2.17	9.96	6.63	3.83	.83	.....
22	.51	.66	.52	3.83	8.13	2.13	7.42	4.50	3.08	.81	.....
23	.54	.64	.52	3.29	6.13	2.25	5.58	3.79	2.46	.77	.....
24	.55	.63	.54	2.83	5.67	2.29	4.88	4.44	2.33	.75	.....
25	.18	.58	.58	3.33	5.29	2.67	4.00	3.75	2.08	.75	.....
26	.34	.58	.58	4.04	5.13	3.21	3.46	3.33	1.81	.74	.....
27	.87	.62	.65	4.79	4.42	3.54	3.08	3.04	1.63	.75	.....
28	.60	.60	.73	3.92	3.83	4.48	2.75	2.58	1.52	.75	.....
29	.53	.58	.88	2.96	3.38	4.46	2.50	2.42	1.47	1.00	.....
30	.98	.....	.83	2.60	2.98	3.88	2.42	2.33	1.38	1.29	.....
31	.87	.....	.75	.....	3.71	.....	2.29	2.29	.....	3.81	.....

Kansas River at Lawrence, Kansas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.10	0.50	0.50	0.45	1.50	5.20	2.10	1.70	1.40	0.80	3.00	1.00
2	.00	.50	.45	.35	1.45	6.30	2.10	2.55	1.25	.80	2.70	1.00
3	—.25	.45	.45	.35	1.55	5.80	3.60	2.25	1.10	.80	2.30	.80
4	—.75	.45	.40	.35	1.45	5.20	5.20	1.90	1.00	.80	2.30	.90
5	.00	.40	.45	.40	2.70	4.20	5.60	1.90	1.00	.70	2.10	1.00
6	.00	.45	.40	.45	4.30	4.40	5.10	1.90	1.00	.75	1.80	1.20
7	+.10	.55	.40	.45	3.80	4.70	3.90	1.70	1.00	.65	1.60	1.20
8	.05	.55	.40	.50	2.90	4.30	2.55	1.90	.80	.60	1.40	1.20
9	.17	.60	.40	.55	2.55	4.10	2.45	2.15	.80	.60	1.20	1.05
10	.17	.65	.40	.50	2.30	4.25	2.20	1.90	.80	.60	1.10	1.00
11	.15	.50	.40	.45	1.90	4.70	2.25	1.50	.80	.80	1.00	1.00
12	.30	.50	.35	.65	1.75	3.85	2.40	1.35	.80	.80	1.00	1.00
13	.25	.50	.25	.70	1.60	3.30	2.40	1.30	1.20	.80	1.00	1.00
14	.25	.50	.05	.60	1.80	2.90	2.25	1.25	1.40	.70	1.00	1.00
15	.30	.50	.35	.60	2.20	2.40	1.95	1.20	3.20	.70	1.00	.90
16	.35	.45	.40	.55	4.90	1.95	1.80	1.60	3.10	.60	.90	.90
17	.30	.45	.20	.60	5.70	1.75	1.60	2.25	2.60	.80	.80	.90
18	.30	.55	.35	.65	4.70	1.65	1.80	3.00	2.00	.60	.80	.85
19	.30	.40	.30	2.85	3.80	1.55	6.00	3.40	1.60	.60	.80	.90
20	.40	.40	.35	3.20	4.90	1.35	7.70	4.50	1.60	.60	.80	.80
21	.35	.40	.40	3.10	4.85	1.40	6.60	4.70	2.10	.55	.80	.80
22	.30	.50	.40	2.55	5.55	1.35	5.10	3.20	2.40	.50	.80	.80
23	.25	.50	.40	2.10	4.00	1.40	3.80	2.60	1.90	.50	.80	.80
24	.30	.45	.35	1.90	4.00	1.55	3.30	3.00	1.50	.50	.80	.80
25	—.30	.45	.40	1.90	3.50	1.65	2.90	2.60	1.30	.55	.80	.80
26	—.05	.45	.30	2.80	3.50	1.95	2.40	2.25	1.20	.55	1.00	.85
27	—.10	.40	.30	3.00	3.00	2.25	2.10	1.90	1.20	.50	.90	.90
28	—.40	.45	.35	2.80	2.65	2.90	1.80	1.70	1.00	.50	.80	.85
29	+.10	.40	.45	2.00	2.30	2.90	1.70	1.45	1.00	.60	1.00	.80
30	.40	.....	.50	1.65	2.00	2.50	1.55	1.50	.90	.90	1.80	.80
31	.55	.....	.50	.....	2.20	.....	1.55	1.45	.....	2.15	.....	.80

Arkansas River at Canyon, Colorado.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.45	2.40	2.40	2.50	3.05	4.45	2.30	2.40	2.60	2.15	2.30	3.55
2	2.50	2.45	2.30	2.60	3.05	4.00	2.30	2.30	2.50	2.10	2.80	5.50
3	2.50	2.40	2.30	2.60	3.30	3.95	2.25	2.20	2.25	2.10	2.30	3.00
4	2.50	2.50	2.30	2.50	3.35	3.70	2.30	2.00	2.20	2.10	2.80	.....
5	2.55	2.50	2.40	2.50	3.40	3.65	2.30	1.95	2.20	2.10	2.30	2.80
6	2.45	2.50	2.40	2.50	3.60	3.70	2.20	2.50	2.10	2.10	2.35	.....
7	2.50	2.60	2.40	2.50	3.80	3.50	2.20	2.35	2.10	2.05	2.40	.....
8	2.50	2.60	2.40	2.50	3.90	3.40	2.20	2.00	2.05	2.15	2.30	.....
9	2.50	2.50	2.50	2.40	3.75	3.30	2.20	1.90	1.95	2.20	2.35	.....
10	2.50	2.50	2.50	2.50	3.60	3.35	2.15	1.90	2.25	2.20	2.40	.....
11	2.50	2.50	2.50	2.40	3.55	3.40	2.20	1.90	2.30	2.20	2.50	.....
12	2.45	2.35	2.40	2.40	3.50	3.30	2.20	1.80	2.25	2.20	2.60	2.50
13	2.50	2.35	2.40	2.40	3.40	3.20	2.15	1.80	2.20	2.20	2.50	.....
14	2.50	2.45	2.40	2.60	3.20	3.10	2.10	1.80	2.15	2.20	2.50	.....
15	2.50	2.45	2.50	2.70	3.10	3.10	2.05	1.80	2.10	2.20	2.50	.....
16	2.50	2.45	2.50	2.80	3.00	3.00	2.96	1.80	2.10	2.20	2.50	.....
17	2.50	2.45	2.60	2.90	2.90	3.05	3.57	2.75	2.10	2.20	2.50	.....
18	2.50	2.45	2.60	2.85	2.80	3.00	3.20	2.45	2.20	2.10	2.40	.....
19	2.50	2.45	2.50	2.75	2.80	3.00	3.20	2.50	2.35	2.10	2.45	2.40
20	2.50	2.45	2.50	2.70	2.85	2.95	2.80	2.40	2.45	2.10	2.50	.....
21	2.50	2.45	2.40	2.60	2.95	2.90	2.70	2.60	2.30	2.10	2.60	.....
22	2.55	2.45	2.50	2.60	3.05	2.80	2.70	2.50	2.30	2.15	2.50	.....
23	2.55	2.55	2.60	2.50	3.15	2.80	2.60	2.50	2.30	2.20	2.50	.....
24	2.50	2.55	2.60	2.60	3.70	2.70	4.13	2.40	2.20	2.20	2.40	.....
25	2.50	2.50	2.80	2.75	3.80	2.70	2.90	2.35	2.20	2.20	2.40	.....
26	2.45	2.45	2.80	2.85	4.00	2.60	2.80	2.15	2.20	2.20	2.20	2.70
27	2.45	2.45	2.90	2.95	4.00	2.50	2.70	2.00	2.20	2.20	2.10	.....
28	2.45	2.40	3.20	3.00	4.20	2.50	2.60	1.95	2.20	2.20	2.00	.....
29	2.50	2.40	2.50	3.05	4.25	2.40	2.60	2.00	2.20	2.20	2.00	.....
30	2.50	.....	2.50	3.10	4.50	2.40	2.45	4.60	2.20	2.30	2.00	.....
31	2.45	.....	2.40	.....	4.60	.....	2.40	2.80	.....	2.30	.....	.....

Arkansas River at Pueblo, Colorado.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.35	0.60	0.40	0.30	0.75	2.30	0.40	0.30	0.60	0.35	0.30	0.20
2	.40	.60	.40	.30	.65	1.95	.40	.20	.40	.30	.30	.30
3	.35	.60	.40	.30	.50	1.75	.30	.10	.35	.30	.30	.55
4	.35	.60	.40	.30	.85	1.70	.40	.10	.40	.20	.30	.60
5	.70	.60	.40	.30	1.25	1.65	.30	.10	.20	.20	.30	.55
6	.60	.60	.40	.30	1.40	1.60	.30	.10	.15	.20	.30	.50
7	.60	.60	.40	.30	1.65	1.60	.25	.10	.05	.20	.30	.50
8	.60	.60	.35	.40	1.85	1.45	.65	.10	.15	.20	.25	.60
9	.60	.60	.30	.30	1.80	1.25	.45	.05	.10	.20	.25	.55
10	.60	.60	.30	.30	1.50	1.35	.30	.00	.10	.30	.30	.50
11	.60	.60	.30	.30	1.40	1.25	.35	.00	.25	.30	.40	.40
12	.60	.60	.20	.40	1.45	1.05	.30	.00	.35	.30	.40	.35
13	.60	.50	.20	.40	1.45	.95	.25	.00	.35	.30	.30	.30
14	.60	.50	.40	.40	1.30	.85	.20	.00	.30	.30	.30	.45
15	.60	.60	.30	.40	1.00	.90	.20	.00	.20	.35	.30	.40
16	.60	.60	.40	.40	.90	.95	.20	.00	.20	.30	.35	.40
17	.60	.50	.35	.40	.90	.95	1.30	1.40	.15	.30	.35	.35
18	.60	.40	.40	.40	.85	.90	1.35	5.05	.15	.30	.30	.30
19	.60	.30	.40	.35	.80	.80	1.10	1.00	.45	.30	.25	.30
20	.60	.30	.40	.35	.75	.80	1.10	.80	.50	.20	.30	.30
21	.60	.30	.35	.25	.75	.50	.75	.40	.40	.20	.30	.30
22	.60	.30	.40	.15	.85	.80	.70	2.40	.65	.20	.30	.40
23	.60	.30	.40	.20	1.05	.70	.60	1.05	.40	.25	.50	.30
24	.60	.30	.40	.30	1.30	.60	2.83	.75	.25	.30	.45	.20
25	.60	.30	.40	.60	1.70	.60	2.05	.55	.25	.30	.40	.20
26	.60	.30	.40	.80	1.80	.60	.80	.40	.30	.30	.40	.35
27	.60	.30	.50	1.45	1.80	.60	.70	.40	.50	.30	.75	.40
28	.60	.30	.50	1.40	1.85	.45	.80	.30	.40	.20	.35	.30
29	.60	.30	.40	1.25	2.05	.50	.60	.25	.40	.40	.10	.30
30	.60	.....	.35	.90	2.05	.40	.50	.25	.40	.30	.10	.25
31	.60	.....	.30	.....	2.50	.....	.40	1.65	.....	.30	.....	.30

Purgatoire River at Trinidad, Colorado.

Day.	May.	June. *a*	July.	Aug.	Sept.	Oct.	Nov.
1	3.15	3.90	3.45	3.65	3.60	3.60	3.70
2	3.15	3.30	3.30	3.80	3.60	3.60	3.70
3	3.10	3.15	3.20	3.70	3.80	3.55	3.70
4	3.15	3.13	3.25	3.55	3.60	3.60	3.60
5	3.10	3.10	3.25	3.60	3.65	3.60	3.60
6	3.20	3.10	3.20	3.70	3.55	3.60	3.60
7	3.10	3.10	3.05	3.55	3.40	3.70	3.70
8	3.15	3.10	2.75	3.50	3.40	3.60	3.70
9	3.15	3.10	2.80	3.40	3.45	3.70	3.70
10	3.15	3.00	.....	3.40	3.45	3.70	3.70
11	3.10	3.00	3.35	3.30	3.40	3.70	3.70
12	3.15	2.85	3.10	3.30	3.35	3.70	3.65
13	3.20	2.75	2.95	3.60	3.30	3.70	3.60
14	3.30	2.55	2.80	3.25	3.30	3.75	3.60
15	3.15	.....	2.80	3.30	3.30	3.80	3.60
16	3.20	.....	3.80	3.30	3.30	3.80	3.60
17	3.20	.....	3.40	3.25	3.70	3.70	3.60
18	3.15	.....	3.45	4.65	3.80	3.70	3.60
19	3.15	2.80	3.50	3.40	3.85	3.70	3.60
20	3.15	2.80	3.40	3.50	3.80	3.70	3.60
21	3.05	.....	3.60	3.70	3.75	3.70	3.60
22	3.00	.....	3.30	3.60	4.20	3.70	3.60
23	3.00	.....	3.30	3.75	4.00	3.70	3.60
24	3.10	.....	4.80	3.65	3.90	3.75	3.60
25	3.10	.....	5.45	3.50	3.70	3.75	3.60
26	3.05	2.85	4.15	3.50	3.65	3.80	3.60
27	3.15	3.00	3.90	3.45	3.70	3.70	3.60
28	3.10	3.15	3.80	3.40	3.70	3.80	3.60
29	3.15	3.25	3.80	3.40	3.70	3.80	3.60
30	3.20	3.35	3.70	3.40	3.65	3.90	3.60
31	3.35	.....	3.70	5.05	.....	3.80	.....

a June 15 to 18, 20 to 26, river dry.

Arkansas River at Hutchinson, Kansas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.95	2.50	1.90	1.50	1.60	1.30	1.55	1.80	1.20	1.30	1.75	(a)
2	1.90	2.50	1.85	1.50	1.55	1.30	1.50	1.65	1.20	1.30	1.60	(a)
3	1.85	2.45	1.70	1.50	1.50	1.30	1.55	1.80	1.20	1.30	1.60	1.70
4	1.80	2.40	1.70	1.50	1.50	1.30	1.60	1.90	1.20	1.30	1.60	1.60
5	2.15	2.40	1.85	1.50	1.45	1.30	1.50	1.85	1.20	1.30	1.60	1.60
6	2.20	2.40	1.90	1.50	1.40	1.30	1.50	1.80	1.20	1.30	1.60	1.60
7	1.95	2.40	1.80	1.45	1.40	2.35	1.50	1.80	1.20	1.30	1.60	1.60
8	1.90	2.40	1.80	1.50	1.40	2.65	1.50	1.80	1.20	1.30	1.50	1.60
9	1.85	2.30	1.90	1.50	1.40	2.00	1.50	1.65	1.20	1.30	1.50	1.60
10	1.85	2.20	1.95	1.45	1.50	1.80	1.55	1.60	1.20	1.40	1.50	1.60
11	1.80	2.20	1.90	1.45	1.45	1.70	1.50	1.50	1.20	1.40	1.50	1.60
12	1.90	2.15	1.90	1.55	1.40	1.70	1.45	1.50	1.20	1.30	1.50	1.60
13	2.10	2.10	1.85	1.70	1.40	1.65	1.40	1.50	1.20	1.30	1.50	1.60
14	2.25	2.10	1.90	1.65	1.50	1.55	1.40	1.40	1.50	1.30	1.50	1.60
15	2.40	2.10	1.90	1.60	1.60	1.50	1.40	1.40	1.45	1.30	1.50	1.60
16	2.40	2.00	2.25	1.65	1.70	1.50	1.50	1.40	1.35	1.30	1.50	1.60
17	2.40	2.00	1.85	1.90	1.70	1.60	1.60	1.40	1.30	1.30	1.50	1.60
18	2.30	2.00	1.90	2.20	1.65	1.55	2.30	1.40	1.40	1.30	1.50	1.80
19	2.35	2.05	1.95	2.15	1.55	1.50	3.15	1.40	1.55	1.30	1.50	1.70
20	2.40	2.10	1.90	2.10	1.55	1.40	2.65	1.40	1.40	1.30	1.50	1.60
21	2.40	2.10	1.80	2.00	1.50	1.60	2.25	1.40	1.35	1.30	1.50	1.60
22	2.40	2.15	1.80	2.00	1.50	1.80	2.22	1.40	1.30	1.50	1.50	1.50
23	2.50	2.10	1.80	2.05	1.50	2.35	2.20	1.30	1.30	1.50	1.50	1.50
24	2.45	2.10	1.75	1.95	1.50	2.65	2.85	1.30	1.30	1.50	1.40	1.50
25	2.40	2.10	1.70	1.90	1.40	2.30	3.00	1.30	1.30	1.50	1.40	1.50
26	2.85	2.10	1.70	1.80	1.50	1.95	2.40	1.30	1.30	1.50	2.00	1.50
27	2.90	2.15	1.60	1.80	1.60	1.75	2.15	1.30	1.30	1.50	2.00	1.55
28	2.80	1.95	1.60	1.85	1.45	1.70	2.00	1.30	1.30	1.50	(a)	1.60
29	2.75	1.90	1.60	1.75	1.40	1.70	1.95	1.30	1.30	2.00	(a)	1.60
30	2.60	.....	1.55	1.65	1.30	1.60	1.85	1.30	1.30	2.05	(a)	1.50
31	2.50	.....	1.50	.....	1.30	.....	1.80	1.30	.....	1.85	.....	1.60

a Ice.

Verdigris River at Liberty, Kansas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.60	3.50	3.00	3.00	3.50	4.55	4.00	2.90	1.90	2.35	5.40	4.40
2	4.45	3.80	2.90	2.90	3.40	4.35	3.65	2.80	1.90	2.25	4.45	4.10
3	4.05	4.00	2.80	2.80	3.40	4.20	3.45	2.70	1.90	2.15	3.90	3.90
4	3.85	3.90	2.80	2.80	3.80	4.05	3.40	2.60	1.90	2.10	3.65	3.90
5	4.00	3.80	2.80	2.80	6.05	3.85	6.70	2.55	1.90	2.10	3.45	3.80
6	3.90	3.60	2.80	2.80	4.20	3.80	5.40	2.45	1.90	2.00	3.40	.....
7	3.90	3.60	2.80	2.80	3.55	3.65	4.35	2.35	1.95	2.00	3.30	3.80
8	3.90	3.50	2.80	2.80	3.25	14.75	3.80	2.30	1.95	2.00	3.20	.....
9	3.90	3.40	2.80	2.80	3.05	21.66	3.50	2.10	1.90	1.95	3.20	.....
10	3.90	3.30	2.80	3.00	2.90	12.75	3.40	2.10	1.80	1.90	3.10	3.80
11	3.90	3.40	2.80	5.40	2.80	5.25	3.30	2.10	1.80	1.90	3.10	.....
12	3.90	3.40	2.80	4.40	2.70	4.65	3.20	2.10	1.70	1.90	3.00	3.60
13	3.90	3.40	2.80	3.80	2.70	4.15	3.10	2.10	1.70	1.90	2.95	.....
14	3.90	3.40	2.80	3.50	2.70	3.95	3.00	2.10	1.70	1.90	2.90	3.40
15	3.90	3.40	2.80	3.40	2.70	3.75	2.90	2.10	1.70	1.85	2.80	.....
16	3.90	3.30	2.80	3.30	8.45	3.55	2.80	2.10	1.70	1.80	2.80	3.20
17	3.80	3.30	3.00	3.20	11.25	3.40	2.70	2.00	1.70	1.80	2.70	.....
18	3.70	3.30	3.10	3.10	10.65	3.30	2.70	2.00	1.70	1.80	2.70	3.10
19	3.70	3.20	3.20	3.00	6.80	3.20	7.00	2.00	2.60	1.80	2.65	.....
20	3.70	3.20	3.20	3.00	12.25	3.10	16.25	2.00	3.35	1.80	2.60	.....
21	3.70	3.10	3.20	3.10	9.95	3.10	16.50	2.00	3.20	1.80	2.60	3.00
22	3.70	3.00	3.20	3.15	6.45	3.15	15.25	2.00	3.00	1.90	2.60	.....
23	3.70	3.00	3.20	3.50	12.65	3.20	7.00	2.00	2.85	2.40	2.60	3.00
24	3.70	3.00	3.20	3.15	23.75	3.20	4.70	2.00	2.65	3.70	2.60	.....
25	3.60	3.00	3.10	5.55	22.75	3.25	4.10	2.00	2.50	4.50	2.60	3.00
26	3.50	3.00	3.10	8.10	20.50	3.45	3.90	2.00	2.50	3.85	2.80	.....
27	3.40	3.00	3.10	6.20	19.25	8.40	3.80	2.00	2.50	3.30	14.50	.....
28	3.40	3.00	3.10	4.85	13.00	12.50	3.65	2.00	2.50	3.05	14.00	.....
29	3.40	3.00	3.00	4.45	6.55	8.10	3.45	2.00	2.45	5.25	6.85	.....
30	3.40	.....	3.00	3.90	5.25	4.65	3.15	1.90	2.40	14.00	4.80	.....
31	3.40	.....	3.00	.....	4.80	.....	3.00	1.90	.....	8.50	.....	.....

Neosho River at Iola, Kansas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.95	2.95	2.40	2.30	3.60	4.40	3.30	3.00	2.10	2.10	3.70	3.25
2	2.80	2.95	2.40	2.30	3.40	4.00	3.30	2.85	2.10	2.10	3.35	3.15
3	2.60	2.90	2.40	2.30	3.15	3.90	3.30	2.80	2.10	2.10	2.60	2.85
4	2.50	2.70	2.40	2.30	7.58	3.80	4.35	2.70	2.10	2.10	2.40	2.65
5	2.70	2.70	2.45	2.30	5.00	3.70	4.95	2.60	2.10	2.00	2.35	2.55
6	2.65	2.70	2.45	2.30	3.85	3.70	3.90	2.55	2.10	2.00	2.35	2.50
7	2.55	2.65	2.40	2.30	3.75	3.80	3.80	2.50	2.10	2.00	2.45	2.50
8	2.50	2.55	2.40	3.95	3.40	6.45	3.50	2.40	2.10	2.00	2.40	2.50
9	2.55	2.50	2.40	10.25	3.00	4.85	3.35	2.30	2.10	2.00	2.40	2.50
10	2.50	2.50	2.40	8.10	2.90	4.30	3.20	2.30	2.10	2.00	2.30	2.45
11	2.50	2.50	2.30	6.85	2.85	4.00	2.95	2.30	2.10	2.00	2.30	2.40
12	2.55	2.50	2.30	4.50	2.80	3.95	2.80	2.30	2.10	2.00	2.30	2.40
13	2.50	2.50	2.30	3.75	2.70	3.70	2.75	2.30	2.00	2.00	2.30	2.40
14	2.55	2.50	2.20	3.50	2.70	3.45	2.70	2.20	2.00	2.00	2.25	2.40
15	2.50	2.50	2.20	3.35	3.75	3.35	2.60	2.20	2.00	2.00	2.20	2.40
16	2.50	2.50	2.30	3.35	11.55	3.25	2.60	2.20	2.00	2.10	2.20	2.40
17	2.55	2.40	2.30	3.45	9.45	3.15	2.60	2.20	2.00	2.10	2.20	2.35
18	2.60	2.40	2.30	3.20	7.40	3.05	2.65	2.20	2.00	2.00	2.20	2.30
19	2.60	2.40	2.30	3.05	6.40	3.00	4.45	2.15	2.00	2.10	2.20	2.30
20	2.60	2.40	2.20	3.00	5.55	3.00	5.45	2.10	2.00	2.10	2.20	2.30
21	2.60	2.40	2.20	2.80	4.85	2.95	7.20	2.10	2.00	2.10	2.20	2.30
22	2.60	2.40	2.20	2.90	16.25	2.90	7.75	2.10	2.00	2.05	2.10	2.30
23	2.60	2.40	2.30	4.25	18.25	2.90	5.65	2.10	2.00	2.05	2.10	2.20
24	2.60	2.40	2.40	3.00	20.10	2.90	4.30	2.10	2.10	2.00	2.10	2.20
25	2.60	2.40	2.60	9.50	19.05	3.40	4.00	2.10	2.10	2.00	2.15	2.20
26	2.60	2.40	2.50	7.70	16.50	3.60	3.65	2.10	2.10	2.00	2.80	2.20
27	2.50	2.40	2.40	9.40	15.25	3.45	3.50	2.10	2.10	2.00	4.85	2.20
28	2.50	2.40	2.40	6.95	10.75	3.65	3.30	2.10	2.10	2.00	4.00	2.20
29	2.50	2.40	2.35	4.50	5.70	3.45	3.30	2.10	2.10	2.00	3.55	2.20
30	2.55	.....	2.30	3.85	5.05	3.40	3.20	2.10	2.10	2.05	3.45	2.20
31	2.75	.....	2.30	.....	4.65	.....	3.10	.....	.....	2.85	.....	2.20

Medicine River at Kiowa, Kansas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June. *a*	July.	Aug.	Sept. *b*	Oct.
1	2.50	2.50	2.40	2.40	2.80	2.30	3.65	2.40	1.40	2.10
2	2.60	2.50	2.40	2.40	2.50	2.30	3.50	2.40	1.40	2.20
3	2.60	2.50	2.40	2.40	2.50	2.20	3.10	2.40	1.40	2.20
4	2.70	2.60	2.40	2.40	2.50	2.20	2.80	2.40	1.40	2.20
5	2.70	2.60	2.30	2.20	2.50	2.10	2.80	2.40	1.40	2.20
6	2.60	2.60	2.30	2.20	2.40	1.90	2.70	2.40	1.40	2.10
7	2.60	2.70	2.30	2.00	2.40	1.65	2.60	2.30	1.40	2.20
8	2.60	2.70	2.40	2.00	2.40	1.30	2.60	2.30	1.40	2.20
9	2.60	2.70	2.40	2.00	2.30	1.40	2.60	2.00	.....	2.20
10	2.70	2.70	2.40	1.90	2.20	1.20	2.90	2.00	.....	2.30
11	2.80	2.60	2.40	1.90	2.20	1.20	2.95	2.00	.....	2.35
12	2.70	2.60	2.50	2.20	2.20	1.20	2.90	1.90	.....	2.40
13	2.60	2.60	2.60	2.50	2.30	1.20	2.85	1.90	2.00	2.40
14	2.60	2.60	2.60	2.55	2.30	.....	3.25	1.80	2.00	2.40
15	2.60	2.60	2.70	2.60	2.30	.....	3.80	1.80	2.00	2.40
16	2.70	2.50	2.65	2.60	2.20	.....	5.90	1.80	2.00	2.40
17	2.80	2.50	2.60	2.60	2.10	.....	5.00	1.80	2.00	2.30
18	2.75	2.60	2.50	2.75	2.10	.....	4.70	1.80	2.00	2.30
19	2.65	2.70	2.50	3.75	2.15	.....	5.60	1.80	2.10	2.30
20	2.60	2.70	2.50	3.70	2.20	.....	4.90	1.70	2.35	2.40
21	2.50	2.70	2.50	3.15	2.35	2.00	3.70	1.70	2.40	2.40
22	2.50	2.60	2.50	2.75	2.40	2.20	3.60	1.70	2.20	2.55
23	2.50	2.50	2.60	2.70	3.20	4.00	3.40	1.70	2.20	2.80
24	2.50	2.50	2.60	2.65	3.00	2.95	3.00	1.60	2.20	2.90
25	2.60	2.40	2.60	2.50	2.80	2.93	2.75	1.60	2.20	2.85
26	2.60	2.40	2.60	2.50	2.70	5.50	2.75	1.50	2.20	2.80
27	2.60	2.40	2.60	2.60	2.60	5.35	2.60	1.50	2.10	2.60
28	2.60	2.50	2.50	2.80	2.55	4.75	2.50	1.40	2.10	2.60
29	2.60	2.50	2.45	2.85	2.45	4.25	2.50	1.40	2.10	3.00
30	2.50	.....	2.40	2.80	2.40	3.95	2.55	1.40	2.10	2.95
31	2.50	.....	2.40	.....	2.30	.....	2.50	1.40	.....	2.75

a Water standing in pools from June 14 to 21.
b Water standing in pools from September 9 to 13.

Cimarron River at Arkalon, Kansas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	2.50	2.50	2.50	2.50	2.50	2.50	2.40	2.40	2.30	2.30
2	2.50	2.50	2.50	2.50	2.50	2.40	2.40	2.40	2.30	2.30
3	2.50	2.50	2.50	2.50	2.50	2.40	2.40	2.40	2.30	2.30
4	2.50	2.50	2.50	2.50	2.50	2.40	2.40	2.40	2.30	2.30
5	2.50	2.50	2.50	2.50	2.50	2.40	2.40	2.40	2.30	2.30
6	2.50	2.50	2.50	2.50	2.50	2.40	2.40	2.40	2.30	2.30
7	2.50	2.50	2.50	2.50	2.50	2.40	2.40	2.40	2.30	2.30
8	2.50	2.50	2.50	2.50	2.50	2.40	2.30	2.40	2.30	2.30
9	2.50	2.50	2.50	2.50	2.50	2.40	2.30	2.40	2.30	2.30
10	2.50	2.50	2.50	2.50	2.40	2.40	2.30	2.40	2.30	2.30
11	2.50	2.50	2.50	3.00	2.40	2.40	2.30	2.40	2.30	2.30
12	2.50	2.50	2.50	4.15	2.50	2.40	2.30	2.40	2.30	2.30
13	2.50	2.50	2.50	3.00	2.50	2.40	2.30	2.40	2.30	2.30
14	2.50	2.50	2.50	2.80	2.50	2.40	2.30	2.40	2.30	2.30
15	2.40	2.50	2.50	2.70	2.50	2.40	2.85	2.40	2.30	2.50
16	2.50	2.50	2.50	2.60	2.50	2.40	2.65	2.35	2.30	2.50
17	2.50	2.50	2.50	2.60	2.50	2.40	2.50	2.30	2.30	2.50
18	2.50	2.50	2.50	2.60	2.50	2.40	2.50	2.30	2.30	2.50
19	2.50	2.50	2.50	2.50	2.50	2.30	2.50	2.30	2.30	2.50
20	2.50	2.50	2.50	2.50	2.50	2.30	2.50	2.30	2.30	2.50
21	2.50	2.50	2.50	2.50	2.50	2.40	2.50	2.30	2.30	2.50
22	2.50	2.50	2.50	2.40	2.50	2.40	2.50	2.30	2.30	2.50
23	2.50	2.50	2.50	2.40	2.50	2.40	2.50	2.30	2.30	2.50
24	2.50	2.50	2.50	2.40	2.50	2.40	2.50	2.30	2.30	2.50
25	2.50	2.50	2.50	2.40	2.50	2.40	2.50	2.30	2.30	2.50
26	2.50	2.50	2.50	2.50	2.50	2.40	2.50	2.30	2.30	2.50
27	2.50	2.50	2.50	2.50	2.50	2.40	2.50	2.30	2.30	2.50
28	2.50	2.50	2.50	2.50	2.50	2.40	2.45	2.30	2.30	2.50
29	2.50	2.50	2.50	2.50	2.50	2.40	2.40	2.30	2.30	2.50
30	2.40	.....	2.50	2.50	2.50	2.40	2.40	2.30	2.30	2.50
31	2.40	.....	2.50	.....	2.50	.....	2.40	2.30	.....	2.50

Mora River at Watrous, New Mexico.

Day.	Jan.	Feb.	Day.	Jan.	Feb.	Day.	Jan.	Feb.	Day.	Jan.	Feb.
1	1.90	1.95	9	1.90	1.90	17	1.90	1.90	25	1.90	1.90
2	1.90	1.95	10	1.90	1.90	18	1.95	1.90	26	1.90	1.90
3	1.90	1.95	11	1.90	1.90	19	1.95	1.90	27	1.95	1.90
4	1.90	1.92	12	1.90	1.90	20	1.95	1.90	28	1.95	1.90
5	2.02	1.92	13	1.90	1.90	21	1.95	1.90	29	1.95	1.90
6	2.00	1.92	14	1.90	1.90	22	1.90	1.90	30	1.95	.....
7	1.90	1.92	15	1.90	1.90	23	1.90	1.90	31	1.95	.....
8	1.90	1.92	16	1.90	1.90	24	1.90	1.90			

Rio Grande at Del Norte, Colorado.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.12	2.96	3.12	2.08	4.18	3.62	1.74	1.56	1.60	2.06	1.72	.....
3	3.24	3.02	3.18	2.14	4.56	3.38	1.70	1.52	1.50	2.00	1.64	.....
5	3.28	2.98	3.10	2.46	4.52	3.06	1.64	1.54	1.54	1.98	1.60	1.62
7	3.16	2.86	3.14	3.08	4.30	2.88	1.62	1.52	1.48	1.94	1.58	.....
9	3.20	2.80	3.10	3.20	3.96	2.72	1.68	1.48	1.50	1.88	1.60	.....
11	3.22	2.90	3.04	3.02	3.66	2.52	1.64	1.46	1.74	1.86	1.72	.....
12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.80
13	3.08	2.78	3.16	2.98	3.32	2.34	1.72	1.44	1.62	1.82	1.58	.....
15	3.12	2.72	3.02	3.04	3.24	2.20	1.70	1.42	1.58	1.94	1.56	.....
17	3.18	2.78	2.84	2.94	3.06	2.12	1.92	1.42	1.50	1.84	1.54	.....
19	3.26	3.20	2.76	2.76	3.22	2.10	2.22	1.44	1.52	1.82	1.52	1.72
21	3.22	3.24	2.54	2.78	3.54	1.98	1.92	1.42	2.00	1.78	1.50	.....
23	3.16	3.18	2.50	3.04	3.80	1.92	1.80	1.46	2.28	1.78	1.54	.....
25	3.12	3.24	2.68	3.90	4.00	1.86	1.78	1.44	3.16	1.80	1.52	.....
26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.64
27	3.06	3.20	2.54	4.22	4.08	1.82	1.70	1.40	2.68	1.84	1.48	.....
29	3.00	3.14	2.52	4.04	4.02	1.78	1.64	1.74	2.18	1.82	1.52	.....
30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.64	.....
31	2.98	.....	2.50	4.12	3.94	.....	1.58	1.62	.....	1.76	.....	.....

Rio Grande at Embudo, New Mexico.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	8.35	8.30	8.50	9.50	10.70	9.15	7.30	7.30	7.30	9.30	7.50	8.10
2	8.25	8.30	8.50	9.50	10.65	8.95	7.30	7.30	7.30	8.65	7.40	8.10
3	8.20	8.10	8.55	9.50	10.45	8.80	7.30	7.30	7.30	7.45	7.40	8.00
4	8.35	8.00	8.40	9.45	10.55	8.45	7.30	7.30	7.30	7.50	7.30	8.00
5	8.30	8.05	8.35	9.55	10.85	8.40	7.30	7.30	7.30	7.50	7.30	8.00
6	8.20	8.20	8.35	9.70	11.00	8.25	7.30	7.30	7.30	7.50	7.30	8.00
7	8.30	8.20	8.40	10.05	10.90	8.20	7.30	7.30	7.30	7.50	7.30	8.00
8	8.35	8.30	8.35	10.10	10.65	8.00	7.30	7.30	7.30	7.50	7.30	8.00
9	8.30	8.30	8.30	10.10	10.40	7.90	7.30	7.30	7.30	7.50	7.40	8.00
10	8.30	8.20	8.40	10.20	10.25	7.75	7.30	7.30	7.30	7.50	7.45	7.90
11	8.50	8.15	8.50	10.30	10.10	7.60	7.30	7.30	7.30	7.50	7.50	7.90
12	8.55	8.10	8.60	10.30	9.85	7.60	7.30	7.30	7.30	7.50	7.50	7.90
13	8.10	8.20	8.55	10.30	9.65	7.50	9.65	7.30	7.30	7.50	7.60	7.90
14	8.00	8.25	8.65	10.30	9.60	7.50	7.30	7.30	7.30	7.50	7.40	7.90
15	8.00	8.10	8.70	10.30	9.50	7.50	7.30	7.30	7.30	7.50	7.40	7.90
16	8.10	8.05	8.75	10.30	9.40	7.50	7.30	7.30	7.30	7.50	7.55	7.90
17	8.05	8.20	8.75	10.30	9.40	7.40	7.45	7.30	7.30	7.50	7.95	7.85
18	8.10	8.25	8.60	10.30	9.40	7.40	7.50	7.30	7.30	7.50	8.30	7.80
19	8.00	8.25	9.10	10.05	9.25	7.35	7.50	7.30	7.30	7.50	8.40	7.80
20	8.00	8.30	9.10	9.90	9.10	7.30	7.60	7.30	7.30	8.00	8.40	7.80
21	8.00	8.20	9.05	9.70	9.00	7.30	8.70	7.45	7.30	7.85	8.35	7.80
22	8.10	8.25	8.85	9.70	8.90	7.30	7.30	7.60	7.30	7.70	8.50	7.80
23	8.10	8.20	9.15	9.70	8.90	7.30	8.05	7.40	7.30	7.70	8.50	7.80
24	8.10	8.25	9.35	9.70	8.90	7.30	8.00	7.40	7.30	7.70	8.35	7.80
25	8.00	8.30	9.55	9.80	8.90	7.30	7.40	7.35	7.30	7.70	8.25	7.80
26	8.00	8.30	9.60	9.80	9.00	7.30	7.40	7.30	7.30	7.70	8.20	7.80
27	8.10	8.40	9.70	9.95	9.50	7.30	7.50	7.30	7.30	7.70	8.20	7.80
28	8.20	8.45	10.10	10.65	9.50	7.30	7.50	7.30	7.45	7.70	8.10	.....
29	8.25	8.45	10.30	10.80	9.50	7.30	7.40	7.30	7.70	7.70	8.10	.....
30	8.25	.....	10.20	10.80	9.50	7.30	7.40	7.30	8.30	7.70	8.10	.....
31	8.30	.....	10.00	.....	9.50	7.30	7.30	7.30	.....	7.70	.....	.....

Chama River at Abiquiu, New Mexico.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.90	1.05	.....	1.90	3.05	1.90	1.70	2.25	2.45	2.25	2.25	2.15
2	1.80	.95	.....	2.45	3.35	1.90	1.50	2.10	2.85	2.35	2.45	1.90
3	1.80	1.15	.....	1.80	2.85	1.85	1.50	2.05	2.75	2.25	2.25	2.05
4	1.85	1.20	.....	1.95	2.65	1.05	1.50	1.95	2.85	2.85	2.25	2.20
5	1.75	1.15	.....	2.95	2.65	1.10	1.35	1.80	2.75	2.70	2.40	2.10
6	1.70	1.00	.....	2.85	2.50	1.05	1.30	1.70	2.20	2.85	2.30	2.00
7	1.75	1.10	.....	3.25	2.90	1.45	1.30	1.65	2.65	3.30	2.25	1.90
8	1.70	1.55	.....	4.13	2.85	1.35	1.35	1.50	3.35	3.40	2.30	2.05
9	1.65	1.55	.....	3.60	2.75	1.45	1.80	1.60	3.40	3.15	2.25	2.00
10	1.55	1.20	.....	2.85	2.75	1.75	1.50	1.55	4.40	2.90	2.05	2.00
11	1.70	1.10	1.60	2.70	2.65	1.45	1.55	1.55	4.40	2.80	2.10	1.95
12	1.75	1.30	1.75	2.80	2.50	1.55	1.45	1.60	3.65	2.75	2.25	2.10
13	1.80	1.45	1.90	2.35	2.45	1.35	1.45	1.50	3.45	2.65	2.15	1.90
14	1.75	1.55	1.70	3.65	2.55	1.30	3.75	1.50	2.90	2.70	2.30	2.05
15	1.70	1.10	1.95	3.05	2.35	1.60	2.75	1.45	2.75	2.75	2.25	2.05
16	1.80	.95	1.50	3.35	2.15	1.45	3.15	1.50	2.55	2.70	2.15	2.10
17	1.75	.95	1.50	3.30	2.55	1.35	3.55	1.55	3.15	2.65	2.25	1.95
18	1.75	1.00	1.55	3.40	2.25	1.30	3.00	1.45	3.15	2.60	2.25	2.00
19	1.65	1.45	1.30	2.55	2.35	1.40	3.25	1.50	3.45	2.75	2.10	1.95
20	1.45	1.40	1.30	3.40	2.15	1.10	3.35	1.35	3.05	2.70	2.15	2.05
21	1.70	1.20	1.35	3.85	1.95	1.10	2.85	1.45	2.80	2.75	2.25	2.15
22	1.35	1.10	1.35	4.10	1.85	1.10	3.60	1.50	2.60	2.65	2.10	2.15
23	1.65	1.50	1.45	3.85	2.05	1.25	2.70	1.85	2.55	2.75	2.10	2.05
24	1.70	1.75	1.55	2.95	2.15	1.30	3.50	1.85	2.55	2.85	2.00	1.95
25	1.55	1.55	1.50	3.70	2.10	1.40	2.95	1.80	2.50	2.85	2.35	1.85
26	1.55	1.35	1.70	3.85	2.15	1.25	2.85	1.90	2.30	2.85	2.35	2.00
27	1.55	1.60	2.55	3.85	1.55	1.50	2.75	1.35	2.25	2.85	2.30	.....
28	1.65	2.05	2.25	3.55	1.85	1.70	2.75	1.35	2.35	2.55	2.35	.....
29	1.35	2.15	1.85	3.35	2.10	1.65	2.95	1.45	2.30	2.65	2.15	.....
30	.90	.....	1.95	3.25	1.85	1.70	2.85	1.45	2.20	2.75	2.20	.....
31	1.10	.....	1.70	.....	1.55	.....	2.75	1.15	.....	2.60	.....	.....

Rio Grande at Rio Grande, New Mexico.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.00	.....	.....	6.65	8.25	6.30	4.20	.....	4.25	4.85	4.80	4.40
2	4.90	.....	.....	6.50	7.95	6.25	4.30	4.10	4.20	4.80	4.80	4.70
3	5.05	.....	.....	6.45	7.85	6.10	4.25	4.10	4.15	4.75	4.80	4.90
4	5.15	.....	5.50	6.45	7.90	5.90	4.25	4.00	4.10	4.70	4.75	4.90
5	.....	.....	5.35	6.40	8.10	5.65	4.20	4.00	4.10	4.65	4.70	4.80
6	.....	.....	5.30	6.55	8.15	5.40	4.25	3.98	4.18	4.60	4.70	4.90
7	.....	.....	5.25	6.85	8.35	5.30	4.10	3.90	4.20	4.53	4.58	4.95
8	.....	.....	5.40	7.02	8.50	5.20	4.10	3.90	4.05	4.95	4.58	5.00
9	.....	.....	5.40	7.50	8.35	5.00	4.08	3.90	4.00	4.85	4.65	5.05
10	.....	.....	5.45	7.60	7.75	4.85	4.03	3.90	4.35	5.00	4.70	5.05
11	.....	.....	5.55	7.80	7.45	4.70	4.00	3.88	4.55	4.80	4.70	5.05
12	.....	.....	5.55	7.87	7.25	4.55	4.00	3.83	4.95	4.70	5.00	5.00
13	.....	.....	5.70	7.80	7.10	4.50	4.60	3.85	4.40	4.80	5.10	5.05
14	.....	.....	5.80	7.65	7.00	4.50	5.10	3.80	4.40	4.90	5.10	5.10
15	.....	.....	5.85	7.80	6.90	4.48	4.30	3.80	4.30	5.00	5.10	4.95
16	.....	.....	5.70	7.80	6.55	4.30	4.65	3.80	4.20	4.98	5.10	5.00
17	.....	5.20	5.75	7.95	6.45	4.25	4.85	3.80	4.20	4.75	5.10	5.10
18	.....	5.20	5.65	7.90	6.30	4.20	4.70	3.80	4.80	4.65	5.10	5.00
19	.....	5.20	5.60	7.75	6.00	4.20	5.40	3.80	4.30	4.75	5.10	4.85
20	.....	5.20	5.52	7.50	5.95	4.15	4.75	3.80	4.45	4.70	5.10	4.75
21	.....	5.20	5.80	7.45	5.85	4.10	5.00	3.80	4.50	4.70	5.10	4.80
22	.....	5.20	5.80	7.60	5.80	4.10	5.40	3.73	4.40	4.75	5.10	4.80
23	.....	.....	5.95	7.70	5.80	4.05	5.15	3.70	4.40	5.15	5.10	4.80
24	.....	.....	6.25	7.60	5.85	4.00	4.95	4.33	4.45	5.00	5.10	4.75
25	.....	.....	6.40	7.85	6.00	4.00	4.65	3.95	4.35	5.00	5.15	4.70
26	.....	.....	6.65	7.95	6.25	4.25	4.65	3.90	4.25	4.90	5.13	4.55
27	.....	.....	6.95	8.15	6.35	4.10	4.50	4.00	4.20	4.90	4.95	.....
28	.....	.....	7.20	8.35	6.40	4.10	4.25	4.00	4.30	5.05	4.85	.....
29	.....	.....	7.25	8.40	6.35	4.15	4.20	4.00	5.35	4.90	4.30	.....
30	.....	.....	7.15	8.45	6.45	4.20	4.30	4.00	5.10	4.80	4.35	.....
31	.....	.....	6.90	.....	6.30	.....	4.25	4.13	.....	4.80	.....	.....

Rio Grande at San Marcial, New Mexico.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	7.45	7.20	8.60	9.00	7.30	*a* 5.60	6.00	*b* 5.50	*b* 5.50	6.80	7.20
2	.....	7.55	7.20	8.45	9.00	7.30	*a* 5.60	6.00	*b* 5.50	*b* 5.50	6.65	7.20
3	.....	7.50	7.20	8.30	8.50	7.50	*a* 5.60	6.00	*b* 5.50	*b* 5.50	6.50	7.20
4	.....	7.40	7.20	8.10	8.50	7.40	*a* 5.60	6.00	*b* 5.50	*b* 5.50	6.50	7.20
5	.....	7.40	7.20	7.90	8.50	7.40	7.00	6.00	*b* 5.50	*b* 5.50	6.50	7.20
6	.....	7.40	7.20	7.90	8.50	7.50	7.00	7.00	*b* 5.50	*b* 5.50	6.50	7.20
7	.....	7.35	7.20	8.00	8.50	7.00	*b* 6.60	6.65	*b* 5.50	*b* 5.50	6.50	7.20
8	.....	7.30	7.00	8.00	8.50	7.00	*b* 6.00	5.85	*b* 5.50	*b* 5.50	6.90	7.20
9	.....	7.30	7.00	8.10	8.70	7.00	*b* 6.00	(*b*)	*b* 5.50	*b* 5.50	6.90	7.20
10	.....	7.30	7.10	8.20	8.70	6.65	*b* 6.00	(*b*)	*b* 5.50	*b* 5.50	6.90	7.20
11	.....	7.30	7.10	8.30	8.70	6.40	*b* 6.00	(*b*)	*b* 5.50	*b* 5.50	6.90	7.30
12	.....	7.30	7.10	8.40	8.70	6.20	*b* 6.00	(*b*)	*b* 5.50	*b* 5.50	6.90	7.30
13	.....	7.30	7.00	8.70	8.50	*a* 6.00	*b* 6.00	(*b*)	*b* 6.25	6.95	6.90	7.30
14	.....	7.30	7.00	8.90	8.50	*a* 6.00	*b* 6.00	(*b*)	6.65	9.45	6.90	7.50
15	.....	7.50	7.20	8.90	8.30	*a* 6.00	*b* 6.00	(*b*)	5.75	11.00	7.00	7.50
16	.....	7.40	7.20	8.60	8.20	*a* 6.00	*b* 6.00	*b* 5.50	*b* 5.50	8.50	7.00	7.50
17	.....	7.40	7.40	8.50	8.00	*a* 6.00	*b* 6.00	*b* 5.50	*b* 5.50	7.00	7.00	7.25
18	.....	7.40	7.40	8.60	7.50	*a* 6.00	*b* 6.55	*b* 5.50	*b* 5.50	7.00	7.00	7.25
19	.....	7.40	7.40	8.65	7.50	*a* 6.00	6.70	*b* 5.50	*b* 5.50	7.00	7.00	7.40
20	.....	7.40	7.58	8.40	7.50	*a* 5.90	7.50	*b* 5.50	7.50	7.25	7.00	7.35
21	.....	7.45	7.60	8.40	7.50	*a* 5.60	9.00	*b* 5.50	7.95	6.00	7.00	7.30
22	7.50	7.50	7.40	8.40	7.20	*a* 5.60	8.25	*b* 5.50	7.60	6.00	7.00	7.30
23	7.45	7.40	7.40	8.40	7.00	*a* 5.60	7.60	*b* 5.50	7.00	6.00	7.10	7.30
24	7.40	7.40	7.50	8.40	7.00	*a* 5.60	7.00	*b* 5.50	7.00	6.95	7.10	7.50
25	7.40	7.40	7.50	8.45	7.00	*a* 5.60	7.00	*b* 5.50	6.75	6.80	7.10	7.50
26	7.50	7.40	7.50	9.00	7.00	*a* 5.60	6.50	7.50	*b* 6.50	6.80	7.10	7.43
27	7.60	7.30	7.60	9.00	7.00	*a* 5.60	6.90	7.50	*b* 6.50	6.80	7.10	.....
28	7.45	7.30	7.70	9.00	7.00	*a* 5.60	8.00	7.50	*b* 6.50	6.80	7.10	.....
29	7.40	7.30	7.90	9.00	7.00	*a* 5.60	8.00	7.45	*b* 6.50	6.80	7.22	.....
30	7.30	.....	7.90	9.00	6.95	*a* 5.60	7.50	6.90	*b* 6.50	6.80	7.20	.....
31	7.40	.....	8.20	.....	7.10	.....	7.00	*b* 5.50	.....	6.80	.....	.....

a No water running. *b* Dry.

Rio Grande at El Paso, Texas.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.85	7.30	6.60	6.00	8.65	5.40	5.10	6.70	0.00	5.55	7.25	6.55
2	6.05	7.30	6.70	7.20	8.80	5.35	5.80	6.55	5.70	7.05	7.15	6.60
3	5.95	7.30	6.85	8.55	8.80	5.35	5.25	6.40	5.25	7.60	6.90	6.60
4	6.00	7.30	6.90	8.60	8.80	5.30	5.15	6.30	5.25	7.50	6.80	6.60
5	5.95	7.30	6.80	8.45	8.80	5.30	5.10	6.05	5.05	8.00	6.70	6.50
6	6.10	7.30	6.70	8.35	8.80	5.25	5.10	5.35	4.80	7.45	6.65	6.50
7	6.20	7.35	6.70	8.15	8.80	5.20	4.90	5.55	.00	7.50	6.60	6.50
8	6.30	7.50	6.70	7.90	8.70	5.25	.00	5.45	.00	7.30	6.60	6.60
9	6.30	7.45	6.75	7.70	8.50	5.15	.00	5.35	.00	7.05	6.50	6.55
10	6.25	7.35	7.70	7.55	8.50	5.15	.00	5.35	.00	7.40	6.40	6.55
11	6.15	7.25	7.35	7.45	8.65	5.15	.00	5.25	.00	7.20	6.35	6.50
12	6.40	7.20	7.30	7.30	8.75	4.95	.00	5.25	.00	7.00	6.30	6.40
13	6.40	7.10	7.10	7.50	8.85	5.05	.00	5.20	.00	6.90	6.20	6.35
14	7.35	7.10	7.00	8.05	8.75	5.10	.00	5.20	.00	7.00	6.10	6.40
15	7.40	7.05	6.80	8.95	8.65	5.00	.00	5.00	.00	8.65	6.10	6.50
16	7.40	7.20	6.50	8.90	8.55	4.80	.00	4.90	.00	10.15	6.10	6.40
17	7.60	7.10	6.40	8.65	8.35	4.45	5.15	4.75	.00	10.60	6.10	6.40
18	7.40	7.00	6.30	8.50	8.10	4.30	8.38	4.60	.00	10.55	6.10	6.35
19	7.45	6.90	6.20	8.45	8.00	4.10	7.35	4.60	.00	8.75	6.10	6.50
20	7.50	6.95	6.10	8.45	7.85	3.80	7.25	4.40	.00	8.15	6.10	6.70
21	7.45	7.15	6.10	8.65	7.65	.....	7.10	4.30	.00	7.75	6.10	6.70
22	7.30	7.25	6.10	8.90	7.30	.....	7.90	4.60	.00	7.65	6.10	6.70
23	7.30	7.20	6.05	8.80	7.15	.....	7.70	4.40	5.50	7.55	6.10	6.70
24	7.25	7.05	6.35	8.60	7.00	.....	9.60	.00	5.70	7.30	6.10	6.70
25	7.35	7.00	6.75	8.40	6.85	.....	8.70	.00	7.35	7.75	6.30	6.65
26	7.25	7.00	6.65	8.50	6.65	.....	8.20	.00	6.80	8.10	6.30	6.70
27	7.30	7.00	6.35	8.45	6.45	.....	7.55	.00	6.20	8.00	6.40	.....
28	7.20	6.80	6.20	8.50	6.15	.00	7.10	.00	6.05	8.20	6.60	.....
29	7.20	6.70	6.10	8.55	5.95	.00	7.20	.00	6.00	7.70	6.55	.....
30	7.10	.....	6.00	8.55	5.70	.00	7.10	.00	5.75	7.45	6.50	.....
31	7.35	.....	5.90	.....	5.45	.....	7.00	.00	.....	7.25	.....	.....

Grand River at Grand Junction, Colorado.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.70	4.65	1.20	1.05	3.35	4.10	3.50	.....
2	.....	2.65	4.10	1.20	.95	3.40	4.00	3.50	.....
3	.....	2.65	3.65	1.10	.85	3.50	3.95	3.50	3.00
4	.....	3.20	3.45	1.10	.85	3.40	3.85	3.40	.....
5	.....	3.30	3.30	1.05	.70	3.30	3.80	3.30	3.30
6	.....	3.90	3.30	1.00	.70	3.25	3.80	3.20	.....
7	.....	4.00	3.25	1.05	.65	3.15	3.80	3.20	.....
8	.....	4.30	3.15	1.00	.55	3.30	3.70	3.10	.....
9	.....	3.90	2.90	.90	.45	3.50	3.70	3.00	3.10
10	.....	3.80	2.75	.85	.40	4.85	3.70	3.20	.....
11	.....	3.70	3.05	.80	.25	4.30	3.70	3.30	.....
12	1.10	3.55	2.95	.80	.15	4.40	3.70	3.30	3.00
13	1.20	3.20	2.80	.80	.05	4.35	3.70	3.30	.....
14	1.10	2.90	2.45	.85	.00	4.15	3.70	3.20	.....
15	1.30	2.50	2.35	.90	.00	3.95	3.65	3.30	.....
16	1.45	2.30	2.20	.85	.00	3.70	3.60	3.40	.....
17	1.50	1.90	2.15	.85	.00	3.60	3.60	3.40	.....
18	1.50	1.90	2.05	1.00	.00	3.60	3.55	3.25	3.10
19	1.20	1.85	2.00	1.25	.00	3.90	3.50	3.10	3.10
20	1.15	1.85	2.00	1.25	.00	3.80	3.50	3.25	.....
21	1.10	1.90	1.85	1.10	1.63	3.75	3.50	3.40	.....
22	1.10	1.90	1.80	1.00	.40	3.80	3.50	3.40	.....
23	1.60	2.35	1.75	.85	a3.45	7.20	3.50	3.40	.....
24	1.90	3.25	1.65	.80	3.55	5.70	3.50	3.40	2.90
25	2.50	3.70	1.55	1.00	3.90	4.55	3.50	3.40	.....
26	2.70	3.90	1.50	1.40	3.75	4.45	3.50	3.40	.....
27	3.30	4.05	1.50	1.45	3.55	4.40	3.40	3.30	.....
28	3.70	4.45	1.40	1.55	3.35	4.30	3.50	3.10	.....
29	3.15	4.30	1.30	1.55	3.30	4.30	3.50	2.70	2.80
30	2.90	4.55	1.30	1.35	3.30	4.10	3.50	2.50	.....
31	.....	4.40	.....	1.15	3.30	.....	3.50	.....	3.00

a New rod placed in position reading 3 feet higher.

Dolores River at Dolores, Colorado.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	3.20	2.65	4.05	3.75	2.70	2.50	2.70	3.00	2.80
2	3.10	2.35	4.30	3.60	2.65	2.40	2.70	3.00	2.80
3	3.00	3.20	4.40	3.45	2.60	2.40	2.60	3.00	2.95
4	2.90	3.25	4.35	3.40	2.60	2.50	2.60	2.90	2.95
5	2.80	3.40	4.05	3.30	2.70	2.60	2.60	2.90	3.20
6	2.75	3.45	4.30	3.20	2.75	2.50	2.60	2.90	3.40
7	2.60	3.70	4.00	3.20	2.85	2.50	2.50	2.85	3.70
8	2.50	3.75	4.05	3.20	2.90	2.40	2.70	2.80	3.35
9	2.55	3.80	4.10	3.10	3.00	2.40	2.70	2.80	2.90
10	2.60	3.50	4.10	3.10	3.00	2.35	2.80	2.80	2.90
11	2.65	3.50	3.60	3.10	3.15	2.30	3.10	2.80	2.90
12	2.65	3.45	3.80	3.00	3.00	2.30	2.90	2.80	3.00
13	2.70	3.45	3.65	3.00	2.95	2.30	2.75	2.85	3.00
14	2.70	3.35	3.40	2.95	3.00	2.30	2.75	2.90	2.90
15	2.75	3.60	3.20	2.90	3.10	2.25	2.75	2.90	2.75
16	2.70	3.55	3.15	2.90	3.50	2.20	2.70	2.80	2.75
17	2.75	3.65	3.25	2.90	3.05	2.35	2.70	2.80	2.55
18	2.60	3.30	3.30	3.00	3.00	2.45	2.70	2.80	2.65
19	2.60	3.45	3.25	2.90	3.05	2.55	2.70	2.80	2.80
20	2.70	3.45	3.75	2.90	3.00	2.55	2.80	2.80	2.75
21	2.70	3.40	3.80	2.80	2.85	2.60	2.80	2.80	2.75
22	2.85	3.95	3.90	2.80	2.80	2.60	2.65	2.85	2.70
23	2.90	4.05	4.00	2.80	2.85	2.60	4.17	2.80	2.70
24	3.10	4.25	4.10	2.70	2.80	2.60	4.05	2.80	2.70
25	3.40	4.35	4.20	2.70	2.75	2.53	4.40	2.80	2.80
26	3.45	4.50	4.25	2.60	2.70	2.50	3.20	2.80	3.20
27	3.25	4.40	4.15	2.60	2.65	2.50	3.10	2.80	3.20
28	3.20	4.30	4.30	2.65	2.60	2.85	3.10	2.90	3.20
29	3.10	3.95	4.25	2.70	2.60	3.00	3.10	2.80	3.20
30	3.05	3.90	4.10	2.70	2.60	2.85	3.00	2.80	3.20
31	3.05	.....	3.90	.....	2.60	2.80	.....	2.80	.....

Fall Creek at Seymour, Colorado.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	4.00	4.20	3.00	2.70	2.65	3.00	2.60
2	.....	4.00	4.15	3.00	2.60	2.60	3.00	2.50
3	.....	3.95	4.15	2.95	2.60	2.60	2.95	2.55
4	.....	3.90	4.15	2.90	2.60	2.65	2.90	2.55
5	.....	3.95	4.15	2.90	2.60	2.60	2.85	2.55
6	.....	4.05	4.05	2.90	2.60	2.60	2.80	2.55
7	.....	4.05	4.00	2.90	2.60	2.60	2.80	2.25
8	.....	4.15	4.10	2.90	2.60	2.60	2.80	2.40
9	.....	4.20	4.10	3.20	2.60	2.60	2.80	2.60
10	.....	4.05	3.95	3.60	2.60	2.95	2.75	2.50
11	.....	4.00	3.85	3.55	2.60	3.00	2.70	2.50
12	3.10	3.80	3.80	3.50	2.60	2.90	2.70	2.50
13	3.15	3.80	3.85	3.45	2.60	2.80	2.70	2.55
14	3.15	3.70	3.90	3.20	2.60	2.80	2.70	2.45
15	3.05	3.70	3.40	3.00	2.60	2.70	2.70	2.65
16	3.10	3.75	3.40	3.00	2.60	2.70	2.70	2.55
17	3.05	3.75	3.45	3.20	2.50	2.70	2.70	2.45
18	3.05	3.60	3.40	3.30	2.60	2.70	2.70	2.50
19	3.05	3.55	3.35	3.30	2.60	2.75	2.60	2.50
20	3.10	3.55	3.30	3.15	2.60	2.85	2.60	2.45
21	3.15	3.80	3.10	3.00	2.60	2.80	2.60	2.50
22	3.30	3.95	3.10	2.90	2.60	2.80	2.65	2.60
23	3.55	4.35	3.05	2.90	2.55	4.45	2.65	2.60
24	3.80	4.35	3.00	2.90	2.55	4.05	2.60	2.60
25	4.00	4.60	3.00	2.85	2.55	4.75	2.60	2.60
26	4.05	4.90	3.00	2.80	2.60	3.50	2.60	2.65
27	4.00	4.95	3.00	2.80	2.55	3.35	2.60	2.30
28	4.00	4.85	3.00	2.80	2.90	3.25	2.60	2.60
29	3.90	4.75	3.00	2.80	2.85	3.10	2.60	2.90
30	3.85	4.70	3.00	2.80	2.75	3.10	2.85	3.05
31	.....	4.40	.....	2.80	2.70	.....	2.50	.....

Uncompahgre River at Uncompahgre, Colorado.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	4.00	5.00	3.40	3.00	3.08	3.35	3.18
2	4.00	4.80	3.20	2.85	3.10	3.43	3.13
3	3.90	4.20	3.20	2.80	3.18	3.35	3.13
4	4.10	4.40	3.20	2.80	3.10	3.30	3.03
5	4.20	4.30	3.20	2.90	3.10	3.23	3.03
6	4.40	4.25	3.20	2.90	3.10	3.20	3.03
7	4.50	4.25	3.20	2.90	3.05	3.23	3.00
8	4.40	4.45	3.50	2.90	3.00	3.25	3.13
9	4.30	4.40	3.35	2.85	3.13	3.23	3.13
10	4.45	4.30	3.20	2.75	3.13	3.23	3.10
11	4.05	4.10	3.20	2.75	3.48	3.23	3.03
12	4.05	4.15	3.35	2.70	3.35	3.23	3.00
13	3.95	4.10	3.35	2.70	3.23	3.18	3.03
14	3.60	4.15	3.45	2.70	3.20	3.18	3.03
15	3.50	4.00	3.50	2.70	3.23	3.18	3.13
16	3.85	3.85	3.30	2.70	3.18	3.13	3.08
17	3.85	3.85	3.35	2.70	3.10	3.10	3.18
18	3.85	3.90	3.35	2.70	3.15	3.10	3.20
19	4.30	3.75	3.35	2.70	3.18	3.13	3.20
20	4.40	3.80	3.45	2.80	3.23	3.08	3.15
21	5.05	3.75	3.45	2.75	3.25	3.10	3.15
22	5.15	3.70	3.30	2.85	3.40	3.08	3.20
23	5.15	3.50	3.20	3.05	3.90	3.08	3.20
24	5.25	3.75	3.00	3.05	3.98	3.05	3.13
25	5.00	3.75	3.05	3.03	3.65	3.03	3.13
26	5.05	3.60	3.05	3.08	3.58	3.03	3.10
27	5.45	3.50	3.00	3.00	3.48	3.08	3.10
28	5.05	3.60	3.00	3.08	3.45	3.10	3.00
29	4.90	3.50	3.00	3.15	3.43	3.10	3.00
30	4.50	3.45	3.00	3.10	3.40	3.13	3.00
31	4.60	.....	3.00	3.18	.....	3.18	.....

Black's Fork River at Granger, Wyoming.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.20	10.30	3.20	2.40	2.00	1.80	.....	.....
2	.....	3.50	9.40	3.10	2.40	2.60	1.80	.....	.....
3	.....	.....	8.00	3.00	2.40	3.00	1.80	.....	.....
4	.....	3.40	7.70	2.90	2.40	2.20	.....	.....	.....
5	.....	3.40	7.60	2.80	2.30	1.90	1.70	.....	2.90
6	.....	4.00	7.30	2.70	2.30	.....	1.70	.....	.....
7	.....	5.10	.....	2.60	2.20	1.80	1.70	1.92	.....
8	.....	5.00	6.30	2.60	2.00	1.70	1.70	.....	.....
9	.....	5.30	6.70	2.60	.....	1.70	1.70	.....	.....
10	.....	.....	7.10	2.50	1.80	1.70	1.60	.....	.....
11	.....	4.90	7.40	2.40	1.70	1.70	.....	.....	.....
12	.....	4.70	7.10	.....	1.70	1.70	1.70	.....	2.90
13	.....	4.30	6.50	2.40	1.60	.....	1.70	.....	.....
14	.....	3.80	.....	2.70	1.50	1.60	1.70	1.90	.....
15	.....	3.60	6.50	3.30	1.50	1.60	1.70	.....	.....
16	.....	3.50	6.00	3.10	.....	1.60	.....	2.40	.....
17	.....	.....	5.80	2.90	3.30	1.60	.....	2.60	.....
18	3.00	3.30	5.50	3.30	4.90	1.60	.....	2.80	.....
19	2.60	3.30	5.30	.....	5.20	1.50	.....	2.90	2.90
20	2.90	3.30	5.20	3.00	4.10	.....	.....	2.90	.....
21	3.30	3.30	4.90	2.80	5.25	1.60	.....	2.90	.....
22	3.30	3.60	4.60	2.60	4.40	1.90	.....	.....	.....
23	3.40	4.00	4.40	3.70	.....	1.90	.....	2.90	.....
24	3.20	4.60	4.20	2.90	3.90	1.90	1.80	2.90	.....
25	3.20	6.00	4.00	2.90	2.50	2.00	.....	2.90	.....
26	.....	6.60	3.80	.....	2.20	3.90	.....	2.90	2.90
27	3.40	7.00	3.60	2.80	2.10	.....	.....	2.80	.....
28	3.50	7.70	.....	2.80	2.00	2.00	.....	2.70	.....
29	3.50	8.00	3.50	2.70	1.90	1.90	.....	.....	.....
30	3.20	8.40	3.40	2.60	2.40	1.80	.....	.....	.....
31	.....	.....	.....	2.40	2.10	.....	1.97	.....	.....

Green River at Green River, Wyoming.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Dec.
1	.....	1.90	4.77	4.05	2.58	1.62	1.30	1.60
2	.....	1.85	4.97	3.98	2.53	1.65	1.30	1.60
3	.....	1.87	4.85	3.88	2.43	1.60	1.25	1.60
4	.....	1.90	5.15	3.80	2.40	1.60	1.25	1.65
5	.....	1.95	5.45	3.78	2.35	1.55	1.25	1.65
6	.....	1.90	5.35	3.70	2.28	1.55	1.20	1.65
7	.....	2.00	5.25	3.63	2.20	1.50	1.20	1.65
8	.....	2.15	5.02	3.60	2.13	1.50	1.20	1.70
9	1.60	2.22	4.30	3.55	2.08	1.50	1.15	1.70
10	1.55	2.25	4.90	3.50	2.03	1.50	1.15	1.70
11	1.60	2.20	5.35	3.45	1.93	1.50	1.15	1.70
12	1.55	2.15	5.75	3.40	1.90	1.50	1.15	1.70
13	1.50	2.15	5.92	3.35	1.85	1.50	1.15	1.70
14	1.57	2.10	5.82	3.35	1.78	1.45	1.10	1.70
15	1.67	2.05	5.87	3.45	1.73	1.45	1.10	1.70
16	1.70	2.05	5.97	3.70	1.70	1.40	.....	1.70
17	1.70	2.05	5.97	3.70	1.70	1.35	.....	1.70
18	1.62	2.00	6.05	3.55	2.00	1.35	.....	1.70
19	1.55	2.00	6.05	3.50	1.83	1.27	.....	1.70
20	1.52	1.95	6.18	3.43	1.90	1.25	.....	1.70
21	1.57	1.90	6.20	3.33	2.08	1.25	.....	1.80
22	1.57	1.95	6.00	3.25	2.10	1.30	.....	1.80
23	1.55	2.02	5.70	3.08	2.15	1.25	.....	1.80
24	1.50	2.30	5.45	2.98	2.08	1.20	.....	1.80
25	1.50	2.65	5.10	2.90	1.93	1.20	.....	1.80
26	1.57	2.85	4.93	2.88	1.88	1.20	.....	1.80
27	1.67	2.90	4.73	2.80	1.78	1.20	.....	1.80
28	1.85	2.97	4.55	2.73	1.68	1.25	.....	.....
29	1.92	3.37	4.43	2.65	1.58	1.30	.....	.....
30	1.90	3.87	4.23	2.60	1.57	1.30	.....	.....
31	.....	4.27	.....	2.53	1.60	.....	.....	.....

Green River at Blake, Utah.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.55	1.80	1.80	3.60	6.35	8.85	5.95	4.40	2.95	3.10	2.55	.....
2	1.65	1.70	1.80	3.60	6.35	9.30	5.75	4.30	2.85	3.20	2.50	.....
3	1.75	1.70	1.90	3.50	6.00	9.65	5.55	3.95	2.75	3.05	2.50	.....
4	1.85	1.70	2.00	3.45	5.75	9.65	5.35	3.75	2.65	3.00	2.50	.....
5	1.70	1.60	1.95	3.40	5.55	9.45	5.15	3.65	2.50	3.00	2.40	.....
6	1.70	1.70	2.00	3.20	5.55	9.25	5.05	3.60	2.50	2.90	2.40	.....
7	1.60	1.75	2.00	3.00	5.80	9.05	5.00	3.50	2.50	2.85	2.40	.....
8	1.65	1.70	2.00	2.90	6.20	8.95	4.80	3.45	2.45	2.70	2.40	.....
9	1.70	1.70	2.05	2.90	6.55	8.75	4.70	3.35	2.40	2.70	2.35	.....
10	1.60	1.80	2.10	2.90	6.75	8.70	4.60	3.30	2.70	2.70	2.30	.....
11	1.65	1.70	2.10	3.00	6.85	8.70	4.95	3.40	2.65	2.70	2.25	.....
12	1.70	1.60	2.10	3.10	6.90	8.45	4.35	3.35	2.85	2.60	2.20	.....
13	1.60	1.60	2.10	3.20	6.75	8.25	4.20	3.15	2.80	2.60	2.20	.....
14	1.50	1.50	2.20	3.45	6.55	8.20	4.25	3.00	2.70	2.60	2.20	.....
15	1.45	1.50	2.30	3.50	6.40	8.30	4.40	2.90	2.70	2.60	2.15	.....
16	1.55	1.60	2.35	3.70	6.10	8.25	4.30	2.80	2.70	2.60	2.10	.....
17	1.65	1.70	2.40	3.75	5.70	8.15	4.70	2.65	2.80	2.60	2.20	.....
18	1.75	1.70	2.55	3.90	5.45	8.00	4.30	2.60	2.65	2.55	2.30	.....
19	1.60	1.80	2.85	3.85	5.20	7.95	4.45	2.50	2.65	2.50	2.40	.....
20	1.65	1.80	3.15	3.95	5.00	7.75	4.80	2.50	3.45	2.50	2.50	.....
21	1.70	1.90	3.10	4.10	4.85	7.70	4.95	2.65	4.45	2.50	2.40	.....
22	1.75	1.90	2.75	4.45	4.70	7.55	4.70	2.85	3.00	2.50	2.30	.....
23	1.75	1.90	2.70	4.10	4.70	7.50	4.55	3.05	5.55	2.50	2.40	.....
24	1.70	1.80	2.80	3.80	4.70	7.40	4.45	3.20	4.75	2.45	2.50	.....
25	1.60	1.80	2.85	3.60	4.85	7.35	4.40	3.15	4.00	2.40	2.60	.....
26	1.60	1.70	3.05	3.75	5.35	7.15	4.60	3.30	4.25	2.40	2.70	.....
27	1.60	1.75	3.25	4.10	5.80	6.90	4.60	3.40	3.70	2.40	2.65	.....
28	1.70	1.80	3.40	5.00	6.65	6.55	4.65	3.65	3.45	2.55	2.45	.....
29	1.70	1.80	3.55	5.70	7.45	6.35	4.60	4.15	3.35	2.40	.....	.....
30	1.80	.....	3.70	6.10	8.00	6.15	4.50	3.45	3.20	2.55	.....	1.80
31	1.80	.....	3.60	.....	8.40	.....	4.50	3.15	.....	2.65	.....	.....

San Juan River at Arboles, Colorado.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	7.15	7.10	5.70	5.70	5.80	5.85	5.90
2	.....	7.20	7.00	5.70	5.65	5.70	5.85	5.90
3	.....	7.50	6.90	5.70	5.60	5.70	5.90	5.85
4	.....	7.60	6.80	5.70	5.60	6.05	5.90	5.80
5	.....	7.65	6.65	5.70	5.75	5.85	5.85	5.70
6	.....	7.75	6.60	5.85	5.75	5.70	5.80	5.60
7	.....	7.65	6.50	5.85	5.65	5.60	6.00	5.55
8	.....	7.40	6.50	5.70	5.60	5.60	5.90	5.50
9	.....	7.25	6.50	5.75	5.50	5.65	5.80	5.50
10	.....	7.35	6.40	5.75	5.50	6.35	5.95	5.65
11	.....	7.25	6.30	5.70	5.50	6.75	5.90	5.75
12	6.80	7.10	6.30	5.70	5.50	6.45	5.80	5.70
13	6.70	7.05	6.20	5.80	5.50	5.95	5.90	5.70
14	6.70	6.85	6.20	5.85	5.50	5.80	5.80	5.70
15	6.85	6.75	6.10	6.00	5.50	5.75	5.80	5.70
16	6.85	6.65	6.00	5.85	5.50	5.70	5.80	5.75
17	6.70	6.60	6.00	6.30	5.50	5.60	5.80	5.90
18	6.70	6.60	6.00	6.25	5.50	5.60	5.80	5.85
19	6.65	6.80	5.95	6.20	5.50	5.80	5.80	5.80
20	6.60	6.95	5.95	6.35	5.40	6.05	5.80	5.80
21	6.80	7.25	5.90	6.15	5.40	5.95	5.80	5.80
22	6.90	7.25	5.90	6.15	5.40	5.80	5.75	5.80
23	6.80	7.35	5.80	6.20	5.40	5.95	6.05	5.80
24	6.90	7.50	5.80	6.15	5.40	6.90	6.15	5.80
25	7.25	7.60	5.80	6.00	5.50	6.55	5.95	5.80
26	7.60	7.70	5.70	5.95	5.50	6.20	5.85	5.80
27	7.45	7.60	5.65	5.90	5.50	6.10	5.85	5.80
28	7.25	7.55	5.70	5.80	6.50	6.00	6.40	5.80
29	7.15	7.35	5.70	5.80	6.20	5.95	6.10	5.80
30	7.15	7.40	5.70	5.80	6.05	5.90	6.05	5.80
31	.....	7.40	.....	5.75	5.90	.....	5.95	.....

Piedras River at Arboles, Colorado.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	4.65	4.05	2.70	2.60	2.80	3.20	3.00
2	.....	4.75	3.85	2.70	2.60	2.70	3.15	3.00
3	.....	4.80	3.80	2.70	2.50	2.70	3.05	3.00
4	.....	4.85	3.70	2.60	2.50	2.75	3.10	2.95
5	.....	4.90	3.60	2.60	2.60	2.80	3.05	2.85
6	.....	4.95	3.50	2.60	2.60	2.70	3.00	2.80
7	.....	4.65	3.45	2.60	2.55	2.60	3.00	2.80
8	.....	4.50	3.40	2.70	2.50	2.60	3.00	2.75
9	.....	4.30	3.30	2.70	2.50	2.60	3.00	2.70
10	.....	4.35	3.30	2.70	2.50	3.05	3.00	2.85
11	.....	4.25	3.20	2.70	2.40	3.25	3.00	2.80
12	4.00	4.10	3.20	2.70	2.40	3.00	2.90	2.75
13	3.90	4.05	3.20	2.75	2.40	2.90	3.00	2.70
14	3.90	3.85	3.10	2.85	2.40	2.80	3.00	2.70
15	4.05	3.80	3.00	2.80	2.40	2.75	3.00	2.70
16	4.05	3.70	3.00	2.70	2.40	2.70	3.00	2.75
17	3.90	3.70	3.00	2.75	2.45	2.65	3.00	2.80
18	3.85	3.85	3.00	3.00	2.50	2.60	2.90	2.80
19	3.70	3.95	2.90	3.00	2.50	2.75	2.90	2.80
20	3.55	4.10	2.90	2.95	2.40	3.65	2.90	2.80
21	3.65	4.15	2.90	2.80	2.40	3.15	2.80	2.80
22	3.85	4.30	2.80	2.85	2.40	3.00	2.80	2.80
23	3.75	4.35	2.80	2.95	2.45	4.60	2.90	2.70
24	4.00	4.40	2.80	3.05	2.50	5.35	3.05	2.80
25	4.50	4.30	2.75	3.00	2.50	4.45	3.05	2.80
26	4.75	4.45	2.70	2.85	2.50	3.95	3.00	2.80
27	4.60	4.50	2.65	2.80	2.50	3.70	3.00	2.80
28	4.45	4.35	2.70	2.70	3.15	3.55	3.10	2.80
29	4.65	4.25	2.70	2.70	3.30	3.40	3.00	2.80
30	4.65	4.30	2.70	2.70	2.80	3.30	3.00	2.80
31	.....	4.30	.....	2.65	2.90	.....	3.00	.....

Animas River at Durango, Colorado.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	7.20	7.05	5.40	5.20	5.20	6.10	5.40	5.10
2	.....	7.50	6.85	5.40	5.20	5.15	6.00	5.40	.....
3	.....	7.65	6.85	5.30	5.20	5.50	5.95	5.40	5.20
4	.....	7.70	6.85	5.30	5.15	5.10	5.90	5.30	.....
5	.....	7.95	6.75	5.30	5.10	5.10	5.85	5.30	5.10
6	.....	8.00	6.65	5.30	5.10	5.10	5.80	5.25	5.10
7	.....	7.55	6.65	5.25	5.10	5.10	5.85	5.25	.....
8	.....	7.30	6.55	5.25	5.10	5.10	5.70	5.20	.....
9	.....	7.05	6.45	5.30	5.10	5.15	5.70	5.25	.....
10	.....	7.10	6.40	5.30	5.10	5.40	5.65	5.25	5.00
11	.....	6.90	6.25	5.45	5.05	5.90	5.60	5.30	.....
12	6.35	6.65	6.15	5.45	5.00	5.65	5.60	5.30	.....
13	6.15	6.40	6.15	5.45	5.00	5.60	5.65	5.25	5.10
14	6.25	6.40	6.10	5.50	5.00	5.55	5.70	5.25	.....
15	6.45	6.35	6.05	5.50	4.95	5.50	5.60	5.30	5.00
16	6.45	6.25	6.00	5.50	4.90	5.40	5.60	5.25	.....
17	6.40	6.25	5.95	5.55	4.90	5.40	5.60	5.30	.....
18	6.20	6.45	5.90	5.65	4.90	5.35	5.55	5.25	.....
19	6.20	6.65	5.80	5.70	4.90	5.40	5.50	5.30	5.10
20	6.15	6.95	5.80	5.55	4.90	6.35	5.50	5.30	.....
21	6.25	6.95	5.70	5.50	4.90	6.05	5.45	5.30	.....
22	6.35	7.15	5.70	5.45	4.90	5.90	5.60	5.25	5.10
23	6.55	7.30	5.65	5.50	4.90	8.40	5.50	5.20	.....
24	7.05	7.70	5.60	5.55	4.90	9.30	5.50	5.25	5.10
25	7.50	7.85	5.60	5.50	4.90	7.40	5.50	5.20	.....
26	7.90	7.80	5.55	5.40	4.80	6.90	5.40	5.20	5.20
27	7.75	7.75	5.50	5.40	4.80	6.65	5.45	5.15	.....
28	7.45	7.85	5.45	5.40	4.95	6.45	5.50	5.05	.....
29	7.20	7.65	5.50	5.35	5.25	6.20	5.50	5.10	.....
30	7.15	7.55	5.40	5.30	5.30	6.10	5.45	5.10	5.00
31	.....	7.35	.....	5.25	5.20	.....	5.40	.....	.....

Gila River at Buttes, Arizona.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.20	1.90	1.71	1.76	1.48	1.11	0.93	2.75	2.50	2.80	3.80	2.40
2	2.20	1.85	1.71	1.86	1.48	1.10	.90	3.70	2.38	4.70	3.65	2.38
3	2.20	1.80	1.72	1.87	1.47	1.09	.91	2.90	2.25	3.80	3.50	2.38
4	2.15	1.85	1.80	1.88	1.46	1.08	.91	4.40	2.38	5.20	3.30	2.35
5	2.10	1.85	1.79	1.90	1.44	1.07	.88	3.20	2.40	3.70	3.15	2.31
6	2.10	1.80	1.79	1.90	1.41	1.06	.86	3.60	2.25	3.80	3.05	2.30
7	2.00	1.80	1.73	1.89	1.40	1.04	.86	2.50	2.13	3.75	2.95	2.30
8	2.05	1.75	1.79	1.85	1.40	1.03	1.36	2.25	2.70	4.80	2.90	2.30
9	2.05	1.70	1.80	1.81	1.38	1.02	1.20	2.13	3.95	3.90	2.80	2.30
10	2.05	1.70	1.80	1.80	1.37	1.00	1.10	1.98	4.20	3.30	2.73	2.29
11	2.05	1.75	1.79	1.74	1.38	1.00	1.04	1.90	3.15	3.00	2.70	2.28
12	2.05	1.75	1.87	1.70	1.36	.99	1.29	2.00	2.85	3.25	2.65	2.28
13	2.00	1.70	1.88	1.70	1.34	.98	1.24	1.90	2.95	5.00	2.60	2.28
14	2.00	1.70	1.90	1.67	1.32	.97	1.20	1.74	2.95	9.35	2.60	2.27
15	2.00	1.70	1.91	1.64	1.31	.95	1.45	1.70	2.70	7.90	2.58	2.27
16	2.00	1.70	1.92	1.62	1.28	.93	4.50	1.86	2.56	6.90	2.55	2.29
17	1.95	1.70	1.91	1.62	1.27	.92	2.30	1.72	2.20	5.60	2.50	2.30
18	1.95	1.70	1.87	1.62	1.25	.91	2.10	1.85	2.23	4.80	2.50	2.30
19	1.95	1.70	1.86	1.61	1.24	.91	2.10	2.06	2.50	4.10	2.48	2.30
20	1.95	1.70	1.84	1.61	1.24	.91	3.00	2.22	3.43	3.70	2.46	2.28
21	1.95	1.70	1.81	1.60	1.23	.91	5.40	2.00	3.10	3.35	2.44	2.26
22	1.90	1.70	1.79	1.60	1.20	.91	8.10	2.50	2.80	3.30	2.42	2.24
23	1.85	1.74	1.75	1.58	1.21	.90	5.10	2.24	3.00	6.75	2.40	2.23
24	1.80	1.72	1.71	1.55	1.21	.89	9.30	2.41	2.35	5.50	2.38	2.22
25	1.80	1.72	1.71	1.53	1.20	.86	4.60	2.41	2.40	6.30	2.40	2.22
26	1.80	1.72	1.71	1.50	1.18	.90	3.00	2.20	2.25	6.50	2.46	2.23
27	1.80	1.72	1.70	1.50	1.16	1.32	2.80	2.18	2.38	5.50	2.53	2.23
28	1.80	1.72	1.70	1.51	1.15	1.10	2.50	2.10	2.32	6.60	2.50	2.23
29	1.90	1.72	1.68	1.50	1.14	.98	2.15	2.05	2.15	5.00	2.48	2.30
30	1.85	.....	1.66	1.48	1.12	.96	2.10	3.70	2.05	4.60	2.44	2.30
31	1.90	.....	1.70	.....	1.12	.94	2.00	2.90	.....	4.10	.....	2.34

Colorado River at Yuma, Arizona.

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	18.25	19.00	19.08	19.42	20.00	21.83	21.25	19.83	19.83	22.08	19.42	18.92
2	18.25	19.08	19.17	19.42	20.00	22.00	21.17	19.42	19.67	20.83	19.83	18.92
3	18.17	19.17	19.25	19.83	21.50	22.50	21.00	19.50	19.67	20.00	19.17	19.00
4	18.08	19.42	19.33	19.42	22.17	23.25	20.83	19.60	20.33	19.67	19.00	18.83
5	18.00	19.25	19.42	19.42	22.42	23.50	20.67	19.60	20.67	19.33	18.83	18.83
6	18.00	19.25	19.42	20.00	22.60	23.83	20.42	19.60	19.75	19.00	18.83	18.83
7	18.00	19.17	19.42	20.00	22.33	23.92	20.42	19.75	19.60	19.50	18.75	18.83
8	18.00	19.08	19.42	19.92	22.33	24.00	20.25	20.00	19.67	19.00	19.08	18.83
9	18.00	18.92	19.42	19.83	22.25	24.08	20.25	19.92	19.42	18.67	18.92	18.92
10	18.00	18.92	19.42	19.83	22.00	24.00	20.25	19.75	19.00	18.67	18.75	18.83
11	18.00	18.83	19.42	19.75	22.25	23.83	20.25	19.75	18.83	18.67	18.75	18.67
12	17.92	18.83	19.25	19.67	22.33	23.75	20.00	19.75	18.92	18.75	18.83	18.42
13	17.92	18.83	19.17	19.75	22.42	23.42	20.00	19.50	19.33	18.67	18.75	18.08
14	17.92	18.83	19.17	19.83	22.50	23.17	20.00	19.33	18.83	18.67	18.67	17.83
15	18.00	18.83	19.17	19.67	22.60	22.92	20.00	19.25	18.60	18.60	18.50	17.75
16	18.17	18.75	19.17	19.75	22.75	22.75	20.00	19.17	18.42	18.50	18.50	17.50
17	18.17	18.67	19.17	19.75	22.75	22.75	20.00	19.00	18.42	19.00	18.50	17.42
18	18.17	18.67	19.17	19.83	22.60	22.67	20.25	19.08	18.60	19.42	17.92	17.42
19	18.17	18.60	19.08	20.00	22.33	22.42	20.33	19.42	18.83	18.83	18.42	17.50
20	18.17	18.50	19.08	20.00	22.17	22.42	21.00	19.75	18.92	18.83	18.42	17.83
21	18.00	18.50	19.08	19.92	21.92	22.17	20.33	19.00	18.60	18.75	18.42	18.00
22	18.25	18.50	19.08	19.92	21.60	21.92	20.08	19.00	18.92	19.25	18.42	18.17
23	18.42	18.67	19.00	19.83	21.33	21.92	20.67	19.00	19.33	20.00	18.33	18.25
24	18.50	18.75	19.00	19.83	21.08	21.83	20.75	19.00	19.25	19.17	18.25	18.25
25	18.50	18.75	19.00	19.83	20.83	21.67	20.67	18.75	19.50	19.67	18.33	18.33
26	18.50	18.83	19.08	19.92	20.67	21.60	20.50	18.75	18.83	19.19	18.42	18.33
27	18.50	18.92	19.17	20.00	20.50	21.50	20.60	19.00	18.42	19.33	18.50	18.42
28	18.67	18.92	19.25	20.00	20.50	21.50	20.50	19.00	19.50	19.17	18.50	18.42
29	18.75	18.92	19.33	20.00	20.75	21.33	20.50	18.75	23.17	19.33	18.83	18.50
30	18.83	.....	19.50	19.00	20.67	21.25	20.83	18.42	24.50	19.17	18.83	18.50
31	18.92	.....	19.50	.....	21.08	.....	20.75	18.42	.....	19.33	.....	18.50

Humboldt River at Elko, Nevada.

Day.	Jan.	Feb.	Mar.a	Apr.a	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.17	2.40	.....	.....	3.60	5.80	5.50	2.60	2.00	1.95	2.00	2.35
2	2.15	2.45	.....	.....	3.65	5.90	5.40	2.60	2.00	1.97	2.00	2.35
3	2.14	2.45	.....	.....	3.50	6.50	5.20	2.60	2.00	1.97	2.00	2.35
4	2.15	2.30	.....	.....	3.50	7.85	5.00	2.55	2.00	1.98	2.00	2.40
5	2.15	2.47	.....	.....	3.50	7.80	4.55	2.50	2.00	1.98	2.00	2.40
6	2.17	2.47	.....	.....	3.55	7.50	4.50	2.45	2.00	2.00	2.00	2.40
7	2.00	2.30	.....	.....	3.60	7.70	4.45	2.40	1.97	2.00	2.00	2.40
8	2.00	2.34	2.35	.....	3.70	7.65	4.35	2.40	1.95	2.00	2.10	2.35
9	2.00	2.30	.....	.....	3.75	7.55	4.20	2.30	1.95	2.00	2.20	2.30
10	2.00	2.47	.....	.....	3.80	7.55	4.15	2.27	1.93	2.00	2.20	2.35
11	2.00	2.34	.....	3.45	3.90	7.10	3.95	2.25	1.93	2.00	2.25	2.40
12	2.00	2.30	.....	3.45	4.15	7.20	3.90	2.25	1.93	2.00	2.25	2.45
13	2.00	2.35	2.50	3.50	4.20	7.40	3.90	2.25	1.93	2.05	2.30	2.45
14	2.00	2.30	.....	3.50	4.20	7.35	3.80	2.25	1.93	2.05	2.30	2.45
15	2.00	2.30	.....	3.45	4.20	7.30	3.75	2.20	1.93	2.05	2.35	2.45
16	2.17	2.34	.....	3.60	4.10	7.35	3.65	2.20	1.90	2.10	2.35	2.45
17	2.15	2.20	.....	3.80	4.00	7.45	3.60	2.20	1.90	2.10	2.35	2.50
18	2.10	2.20	.....	3.90	3.90	7.45	3.50	2.15	1.90	2.10	2.40	2.50
19	2.14	2.20	.....	3.90	3.90	7.45	3.40	2.10	1.90	2.10	2.40	2.52
20	2.27	2.20	.....	3.90	3.80	7.50	3.20	2.10	1.90	2.10	2.40	2.50
21	2.27	2.20	2.70	3.90	3.70	7.55	3.20	2.10	1.90	2.10	2.40	2.50
22	2.25	2.20	.....	3.95	3.60	7.40	3.10	2.10	1.90	2.10	2.40	2.45
23	2.20	2.25	.....	3.90	3.50	7.20	2.95	2.10	1.93	2.10	2.40	2.45
24	2.20	2.25	.....	3.80	3.55	7.10	2.90	2.10	1.90	2.15	2.00	2.45
25	2.25	2.25	3.20	3.70	3.55	6.90	2.80	2.05	1.90	2.15	2.40	2.50
26	2.25	2.30	.....	3.80	3.55	6.70	2.75	2.05	1.90	2.15	2.40	2.50
27	2.25	2.30	.....	3.70	3.60	6.40	2.75	2.05	1.90	2.15	2.40	2.50
28	2.24	2.30	3.50	3.75	3.70	6.10	2.70	2.05	1.90	2.15	2.40	2.45
29	2.35	2.30	.....	3.75	3.95	5.90	2.70	2.05	1.90	2.15	2.40	2.45
30	2.30	.....	.....	3.70	4.30	5.70	2.65	2.00	1.90	2.15	2.35	2.45
31	2.35	.....	.....	.....	4.55	.....	2.60	2.00	.....	2.15	.....	2.50

a Observations discontinued from March 1 to April 11; gage taken by flood.

Humboldt River at Battle Mountain, Nevada.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	8.15	2.10	0.80	0.80	1.40	1.90
2	.....	8.10	2.00	.85	.80	1.40	1.90
3	.....	8.10	1.90	.90	.80	1.45	1.90
4	.....	8.05	1.80	.90	.80	1.45	1.90
5	.....	7.50	1.75	.90	.80	1.50	1.85
6	.....	7.30	1.70	.85	.80	1.50	1.80
7	.....	7.10	1.60	.85	.80	1.50	1.80
8	.....	6.80	1.50	.85	.80	1.50	1.80
9	.....	6.40	1.45	.80	.85	1.55	1.85
10	.....	6.00	1.40	.80	.85	1.60	1.85
11	.....	5.60	1.40	.80	.85	1.70	1.90
12	.....	5.30	1.35	.80	.85	1.70	1.90
13	.....	5.00	1.30	.80	.85	1.70	1.90
14	.....	4.80	1.25	.80	.85	1.65	1.90
15	.....	4.60	1.20	.80	.90	1.65	2.00
16	.....	4.40	1.15	.80	.90	1.70	2.00
17	.....	4.20	1.15	.75	.95	1.70	2.00
18	.....	4.10	1.10	.75	.95	1.70	2.00
19	.....	4.00	1.05	.75	.95	1.70	2.00
20	.....	3.80	1.00	.75	1.00	1.70	2.05
21	.....	3.70	1.00	.75	1.10	1.75	2.05
22	.....	3.60	1.00	1.10	1.10	1.75	2.05
23	.....	3.50	.95	1.00	1.15	1.80	2.10
24	.....	3.30	.95	.90	1.15	1.80	2.10
25	.....	3.10	.90	.90	1.20	1.80	2.10
26	.....	3.00	.90	.85	1.20	1.80	2.10
27	.....	2.80	.90	.85	1.30	1.80	2.10
28	8.25	2.70	.85	.85	1.35	1.80	2.15
29	8.20	2.60	.85	.85	1.35	1.85	2.15
30	8.20	2.40	.80	.80	1.40	1.85	2.15
31	.....	2.30	.80	.....	1.40	.....	2.20

Humboldt River at Golconda, Nevada.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.65	1.50	0.50	0.30	2.65	4.00	7.40	3.00	0.70	0.30	0.95	1.60
2	.63	1.50	.50	.35	2.70	4.00	7.40	2.90	.70	.30	1.00	1.60
3	.60	1.60	.50	.40	2.70	4.30	7.30	2.80	.60	.35	1.00	1.60
4	.58	1.75	.50	.50	2.70	4.50	7.20	2.60	.60	.40	1.00	1.70
5	.50	1.70	.50	.70	2.70	4.60	7.00	2.50	.50	.40	1.10	1.70
6	.50	1.70	.50	.80	2.80	4.80	6.90	2.40	.50	.50	1.10	1.70
7	.55	1.65	.50	1.60	2.90	4.90	6.60	2.20	.45	.60	1.20	1.80
8	.53	1.70	.50	2.00	3.20	4.90	6.50	2.20	.40	.60	1.20	1.80
9	.53	1.40	.50	2.40	3.20	4.90	6.10	2.10	.40	.60	1.25	1.80
10	.58	1.60	.55	2.10	3.20	5.00	5.80	2.10	.35	.60	1.20	1.85
11	.58	1.70	.60	2.00	3.30	5.30	5.80	2.00	.35	.60	1.20	1.85
12	.55	1.70	.55	1.90	3.30	5.75	5.50	1.90	.30	.60	1.30	1.80
13	.58	1.60	.50	1.70	3.30	5.70	5.20	1.80	.30	.60	1.40	1.90
14	.53	1.50	.50	1.60	3.30	5.90	5.00	1.80	.25	.60	1.50	1.90
15	.60	1.40	.50	1.50	3.30	6.00	4.95	1.60	.25	.60	1.50	2.00
16	.60	1.40	.50	1.55	3.30	6.10	4.85	1.50	.25	.60	1.60	2.00
17	.60	1.35	.40	1.60	3.30	6.40	4.80	1.50	.25	.60	1.60	2.00
18	.65	1.37	.30	1.90	3.35	6.70	4.70	1.40	.20	.60	1.60	2.10
19	.70	1.37	.20	1.70	3.40	6.70	4.50	1.35	.20	.70	1.60	2.10
20	.78	1.25	.20	1.70	3.45	6.80	4.30	1.30	.20	.70	1.60	2.15
21	.85	1.20	.20	2.10	3.40	6.90	4.00	1.20	.20	.70	1.60	2.20
22	.85	1.15	.20	2.00	3.45	6.90	3.90	1.05	.20	.70	1.60	2.20
23	1.05	1.00	.20	2.00	3.50	7.00	3.90	1.00	.20	.70	1.70	2.20
24	1.70	1.00	.20	2.20	3.50	7.00	3.60	1.00	.30	.70	1.70	2.20
25	1.10	.90	.40	2.30	3.50	7.10	3.50	1.00	.30	.75	1.70	2.20
26	1.00	.80	.75	2.30	3.50	7.10	3.50	.90	.30	.80	1.70	2.20
27	1.30	.85	.75	2.40	3.50	7.20	3.40	.80	.30	.80	1.60	2.00
28	1.35	.75	.50	2.50	3.50	7.20	3.40	.80	.30	.80	1.50	2.10
29	1.40	.60	.35	2.60	3.70	7.30	3.40	.75	.30	.90	1.50	2.15
30	1.50	.....	.35	2.60	3.80	7.40	3.10	.70	.30	.90	1.55	2.20
31	1.50	.....	.30	.....	3.90	.....	3.00	.70	.....	.90	.....	2.20

Humboldt River at Oreana, Nevada.

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.72	2.80	2.40	2.04	3.80	7.10	4.70	3.20	2.45	.....	.....
2	.....	2.72	2.80	2.40	2.04	3.70	7.10	4.70	3.20	2.40	.....	.....
3	.....	2.72	2.70	2.40	2.04	3.60	7.20	4.60	3.20	2.40	.....	.....
4	.....	2.73	2.70	2.30	2.04	3.50	7.30	4.45	3.10	2.30	.....	.....
5	.....	2.73	2.50	2.30	2.04	3.40	7.40	4.40	3.10	2.20	.....	.....
6	.....	2.78	2.70	2.30	2.04	3.30	7.50	4.30	3.10	2.15	.....	3.20
7	.....	2.80	2.70	2.30	2.04	3.35	7.50	4.20	3.00	2.10	2.40	.....
8	.....	2.80	2.60	2.20	2.04	3.50	7.50	4.15	2.90	2.10	.....	.....
9	.....	2.80	2.60	2.05	2.04	3.50	7.60	4.10	2.80	2.05	.....	.....
10	.....	2.80	2.60	2.05	2.05	4.20	7.65	4.10	2.70	2.05	.....	.....
11	.....	2.80	2.60	2.05	2.05	4.50	7.60	4.00	2.70	2.05	.....	.....
12	.....	2.80	2.60	2.04	2.06	4.60	7.50	4.00	2.70	2.05	.....	2.70
13	.....	2.80	2.60	2.04	2.06	4.70	7.30	3.90	2.70	2.05	.....	.....
14	.....	2.81	2.60	2.04	2.07	4.80	7.10	3.80	2.65	2.00	.....	.....
15	.....	2.85	2.50	2.04	2.08	4.80	6.90	3.80	2.65	2.00	.....	.....
16	.....	2.81	2.50	2.04	2.09	4.90	6.70	3.70	2.65	2.00	.....	.....
17	.....	2.81	2.50	2.03	2.10	5.10	6.60	3.60	2.60	1.95	.....	.....
18	.....	2.82	2.50	2.03	2.10	5.20	6.40	3.60	2.60	1.95	.....	.....
19	.....	2.83	2.50	2.03	2.10	5.40	6.30	3.50	2.60	1.90	.....	2.80
20	.....	2.84	2.50	2.03	2.80	5.70	6.10	3.40	2.55	1.90	.....	.....
21	.....	2.84	2.50	2.03	3.20	5.70	6.00	3.50	2.55	2.20	.....	.....
22	.....	2.85	2.50	2.03	3.40	5.90	5.80	3.40	3.10	2.25	.....	.....
23	.....	2.83	2.50	2.03	3.70	6.10	5.70	3.30	3.00	2.25	.....	.....
24	.....	2.82	2.60	2.03	4.90	6.20	5.60	3.30	2.90	2.20	.....	.....
25	.....	2.81	2.60	2.03	4.80	6.30	5.40	3.20	2.60	2.20	.....	.....
26	.....	2.81	2.60	2.03	4.60	6.50	5.30	3.10	2.60	2.60	.....	2.80
27	2.70	2.81	2.65	2.04	4.50	6.50	5.20	3.00	2.55	2.50	.....	.....
28	2.70	2.81	2.65	2.04	4.25	6.60	5.10	3.10	2.55	2.40	.....	.....
29	2.70	2.80	2.55	2.04	4.05	6.80	5.10	3.20	2.50	2.40	.....	.....
30	2.71	.....	2.40	2.04	3.95	6.90	5.00	3.20	2.50	2.40	.....	.....
31	2.72	.....	2.40	.....	3.95	.....	4.90	3.20	.....	2.40	.....	.....

Rock Creek at Battle Mountain, Nevada.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1	.....	1.90	3.97	2.70	5.90	2.78	1.80
2	.....	1.70	3.50	2.75	5.70	2.70	.....
3	.....	1.77	3.35	2.85	5.50	2.68	.....
4	.....	1.80	3.27	2.85	5.15	2.65	.....
5	.....	1.75	3.22	2.95	4.95	2.63	.....
6	.....	2.05	2.80	3.05	4.65	2.60	.....
7	.....	1.92	2.60	3.10	4.40	2.58	.....
8	.....	1.90	2.55	3.10	4.10	2.55	.....
9	.....	2.05	2.55	3.15	3.85	2.50	.....
10	.....	2.02	2.50	3.20	3.75	2.50	.....
11	.....	2.05	2.40	3.35	3.50	2.50	.....
12	1.85	2.00	2.30	3.50	3.25	2.45	.....
13	1.80	2.02	2.35	3.65	3.10	2.40	.....
14	1.80	2.14	2.57	3.85	3.08	2.40	.....
15	1.85	2.15	2.82	4.10	3.05	2.35	.....
16	1.80	1.97	2.55	4.20	3.00	2.35	.....
17	1.75	2.10	2.50	4.35	3.00	2.30	.....
18	1.75	2.35	2.47	4.60	2.95	2.25	.....
19	1.80	2.55	2.55	4.95	2.93	2.20	.....
20	1.77	2.80	2.50	5.10	2.86	2.15	.....
21	1.80	3.65	2.50	5.15	2.88	2.10	.....
22	1.80	3.32	2.50	5.20	2.88	2.00	.....
23	1.80	3.37	2.57	5.25	2.85	2.00	.....
24	1.75	3.45	2.50	5.55	2.83	1.95	.....
25	1.85	3.65	2.50	5.80	2.83	1.90	.....
26	1.80	3.85	2.70	5.88	2.80	1.90	.....
27	1.87	4.40	2.65	5.95	2.78	1.85	.....
28	1.92	5.20	2.60	6.00	2.75	1.85	.....
29	1.92	4.60	2.60	6.00	2.75	1.80	.....
30	.....	4.25	2.68	6.10	2.75	1.80	.....
31	.....	4.00	.....	6.15	.....	1.80	.....

South Fork of Humboldt River at Masons Ranch, Nevada.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.00	0.95	1.10	1.10	17	.....	0.80	1.00	1.15	1.40
2	.....	.95	.95	1.10	1.10	18	.....	.80	1.00	1.20	1.30
3	.....	.90	.95	1.10	1.15	19	.....	.80	1.00	1.20	1.30
4	.....	.90	.95	1.10	1.15	20	.....	.80	1.00	1.20	1.30
5	.....	.90	.95	1.10	1.20	21	.....	.80	1.00	1.20	1.20
6	.....	.90	.95	1.10	1.20	22	.....	.90	1.00	1.20	1.20
7	.....	.90	.95	1.10	1.30	23	.....	.90	1.00	1.15	1.20
8	.....	.90	.95	1.10	1.30	24	.....	.95	1.00	1.15	1.10
9	.....	.85	.95	1.10	1.40	25	.....	.95	1.00	1.10	1.10
10	.....	.85	.95	1.10	1.40	26	.....	.95	1.00	1.10	1.00
11	.....	.85	.95	1.15	1.50	27	.....	.95	1.00	1.00	1.00
12	.....	.85	.95	1.15	1.60	28	.....	.95	1.00	1.00	1.00
13	.....	.85	.95	1.15	1.60	29	.....	.95	1.05	1.00	1.00
14	.....	.85	.95	1.15	1.50	30	1.00	.95	1.05	1.00	1.00
15	.....	.85	.95	1.15	1.50	31	1.00	.....	1.05	.....	1.00
16	.....	.80	.95	1.15	1.40						

Bear River at Soda Springs, Idaho.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	.....	.....	5.90	.....	.....	17	.....	8.20	5.90	5.30	.....	.....
2	.....	7.53	.....	.....	5.40	5.35	18	.....	.....	.....	.....	5.30	.....
3	.....	.....	.....	5.85	.....	.....	19	.....	8.00	.....	5.40	.....	.....
4	.....	.....	.....	5.80	5.35	.....	20	.....	7.90	5.85	.....	.....	.....
5	.....	7.70	7.40	.....	5.30	.....	21	.....	.....	.....	5.40	5.30	.....
6	.....	.....	7.30	5.70	.....	.....	22	.....	7.80	5.80	5.40	.....	.....
7	.....	7.93	7.00	5.65	5.30	.....	23	.....	.....	.....	.....	5.35	.....
8	.....	.....	6.90	.....	.....	.....	24	.....	7.70	5.80	5.45	.....	.....
9	.....	8.40	6.60	.....	5.30	.....	25	6.50	.....	.....	.....	5.40	.....
10	.....	8.32	6.30	5.60	.....	.....	26	6.52	7.60	.....	5.40	.....	.....
11	.....	.....	6.00	.....	5.30	.....	27	.....	.....	5.80	.....	.....	.....
12	.....	.....	.....	5.50	.....	.....	28	.....	.....	.....	5.40	5.35	.....
13	.....	8.30	6.00	.....	.....	.....	29	.....	.....	5.80	5.40	.....	.....
14	.....	.....	6.00	5.50	5.30	.....	30	7.10	.....	.....	.....	5.35	.....
15	.....	8.40	5.90	5.40	.....	.....	31	.....	.....	5.95	5.40	.....	.....
16	.....	.....	.....	.....	5.30	.....							

Bear River at Battle Creek, Idaho.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.40	1.30	1.40	2.30	2.70	4.45	3.60	2.10	1.60	1.60	1.70	2.60
2	1.40	1.30	1.40	2.40	2.80	4.65	3.45	2.10	1.60	1.60	1.70	1.90
3	1.40	1.30	1.40	2.50	2.80	4.70	3.25	2.00	1.60	1.60	1.70	1.90
4	1.40	1.30	1.40	2.60	2.80	4.70	3.10	2.00	1.60	1.60	1.80	1.90
5	1.40	1.30	1.40	2.60	2.80	4.80	2.95	2.00	1.60	1.60	1.80	1.90
6	1.40	1.30	1.40	2.70	2.90	4.90	2.80	1.90	1.60	1.60	1.80	.....
7	1.40	1.30	1.40	2.80	2.90	4.80	2.70	1.90	1.60	1.60	1.80	.....
8	1.40	1.30	1.40	2.80	3.00	5.05	2.70	1.80	1.60	1.60	1.80	.....
9	1.40	1.30	1.40	2.80	3.00	5.15	2.60	1.80	1.60	1.60	1.80	.....
10	1.40	1.30	1.40	2.70	3.00	5.45	2.60	1.80	1.60	1.60	1.80	.....
11	1.40	1.30	1.40	2.70	3.00	5.60	2.50	1.80	1.60	1.60	1.70	.....
12	1.40	1.30	1.40	2.70	3.00	5.50	2.50	1.80	1.60	1.60	1.70	.....
13	1.40	1.40	1.40	2.70	3.00	5.35	2.40	1.70	1.60	1.60	1.70	.....
14	1.40	1.40	1.40	2.70	3.00	5.20	2.40	1.70	1.60	1.60	1.70	.....
15	1.40	1.40	1.40	2.70	3.00	5.10	2.40	1.70	1.60	1.60	1.70	.....
16	1.40	1.40	1.40	2.70	3.00	5.00	2.30	1.70	1.60	1.60	1.70	1.80
17	1.40	1.40	1.40	2.70	3.00	5.00	2.30	1.70	1.60	1.60	1.80	.....
18	1.40	1.40	1.40	2.70	2.90	4.90	2.20	1.70	1.60	1.60	1.80	.....
19	1.40	1.40	1.50	2.70	2.90	4.80	2.20	1.70	1.60	1.60	1.80	.....
20	1.40	1.40	1.50	2.70	2.80	4.80	2.20	1.70	1.60	1.60	1.90	.....
21	1.40	1.40	1.50	2.70	2.80	4.70	2.20	1.70	1.60	1.60	1.90	.....
22	1.40	1.40	1.60	2.60	2.70	4.60	2.10	1.70	1.60	1.60	1.90	.....
23	1.40	1.40	1.70	2.60	2.70	4.50	2.10	1.70	1.60	1.60	1.90	1.80
24	1.40	1.40	1.70	2.60	2.80	4.50	2.10	1.70	1.60	1.60	1.90	.....
25	1.40	1.40	1.80	2.60	2.90	4.40	2.10	1.70	1.60	1.60	1.90	.....
26	1.40	1.40	1.90	2.60	3.05	4.30	2.10	1.70	1.60	1.60	2.60	.....
27	1.40	1.40	2.00	2.60	3.25	4.20	2.10	1.70	1.60	1.70	2.60	.....
28	1.40	1.40	2.10	2.70	3.50	4.05	2.10	1.70	1.60	1.70	2.60	.....
29	1.40	1.40	2.10	2.70	3.60	3.85	2.10	1.70	1.60	1.70	2.60	.....
30	1.30	.....	2.20	2.70	4.05	3.70	2.10	1.60	1.60	1.70	2.60	.....
31	1.30	.....	2.30	.....	4.25	.....	2.10	1.60	.....	1.70	.....	.....

Bear River at Collinston, Utah.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.90	1.80	1.70	3.20	3.60	5.60	4.15	2.30	1.80	2.00	2.00	.....
2	1.90	1.80	1.70	3.30	3.60	5.90	3.95	2.30	1.80	1.95	2.00	2.30
3	1.90	1.80	1.70	3.10	3.75	5.90	3.75	2.30	1.80	1.95	2.00	.....
4	1.95	1.70	1.70	3.00	3.75	6.05	3.55	2.30	1.80	1.95	2.00	2.20
5	1.90	1.70	1.70	3.00	3.85	6.15	3.40	2.30	1.80	1.95	2.05	.....
6	1.90	1.70	1.70	3.10	3.95	6.30	3.20	2.20	1.80	1.90	2.05	.....
7	1.90	1.70	1.70	3.10	4.00	6.30	3.10	2.20	1.75	1.90	2.05	.....
8	1.90	1.70	1.70	3.20	4.00	6.20	3.00	2.20	1.75	1.90	2.05	.....
9	1.90	1.70	1.70	3.30	4.10	6.30	2.90	2.10	1.80	1.90	2.05	.....
10	1.90	1.70	1.70	3.30	4.10	6.40	2.80	2.00	1.80	1.90	2.10	.....
11	1.90	1.70	1.70	3.30	4.00	6.40	2.70	2.00	1.80	1.90	2.15	.....
12	1.90	1.70	1.70	3.40	3.95	6.40	2.70	1.95	1.80	1.90	2.20	.....
13	1.90	1.70	1.70	3.40	3.80	6.40	2.60	1.90	1.85	1.90	2.10	.....
14	2.00	1.70	1.70	3.50	3.75	6.55	2.55	1.85	1.90	1.90	2.00	.....
15	2.00	1.70	1.70	3.50	3.60	6.55	2.50	1.80	1.90	1.90	2.00	2.20
16	2.00	1.70	1.70	3.50	3.60	6.30	2.50	1.80	1.85	1.90	2.00	.....
17	2.10	1.70	1.70	3.50	3.60	6.00	2.50	1.75	1.85	1.90	2.05	.....
18	2.10	1.70	1.70	3.60	3.50	5.90	2.50	1.70	1.85	1.90	2.10	2.00
19	2.20	1.70	1.70	3.35	3.50	5.80	2.50	1.70	1.80	1.90	2.10	.....
20	2.30	1.70	1.70	3.25	3.40	5.70	2.40	1.75	1.80	1.90	2.10	.....
21	2.30	1.70	1.70	3.15	3.40	5.60	2.30	1.80	1.80	1.90	2.10	.....
22	2.20	1.70	1.70	3.10	3.40	5.50	2.20	1.90	1.85	1.90	2.15	.....
23	2.10	1.70	1.90	3.10	3.40	5.40	2.20	1.90	1.90	1.90	2.20	.....
24	2.00	1.70	2.00	3.20	3.65	5.35	2.10	1.85	1.90	1.90	2.25	.....
25	2.00	1.70	2.10	3.20	3.90	5.20	2.20	1.80	1.90	1.90	2.30	.....
26	1.70	1.70	2.20	3.10	4.10	5.10	2.25	1.85	1.95	1.90	2.30	.....
27	1.70	1.70	2.30	3.30	4.45	4.80	2.30	1.85	1.95	1.90	2.30	.....
28	1.70	1.70	2.40	3.40	4.65	4.80	2.25	1.90	1.95	2.00	2.30	2.20
29	1.70	1.70	2.70	3.40	4.85	4.60	2.20	1.90	2.00	2.00	.....	.....
30	1.70	.....	2.90	3.50	4.95	4.40	2.20	1.85	2.00	2.00	2.30	2.20
31	1.70	.....	3.00	.....	5.20	.....	2.20	1.80	.....	2.00	.....	.....

Logan River at Logan, Utah.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.80	3.85	3.10	2.80	2.70	2.65	2.60
2	.....	3.80	3.10	2.80	2.70	2.60	2.55
3	.....	3.75	3.10	2.80	2.70	2.60	2.55
4	4.70	3.70	3.10	2.80	2.70	2.60	2.55
5	.....	3.75	3.05	2.80	2.70	2.60	2.55
6	4.90	3.75	3.05	2.75	2.70	2.60	2.55
7	.....	3.70	3.05	2.75	2.70	2.55	2.50
8	.....	3.65	3.00	2.80	2.70	2.60	2.55
9	4.70	3.60	2.95	2.75	2.70	2.70	.....
10	4.70	3.55	2.95	2.75	2.65	2.65	2.55
11	.....	3.55	2.95	2.75	2.65	2.60	.....
12	4.65	3.50	2.95	2.75	2.65	2.60	.....
13	4.60	3.55	2.95	2.75	2.65	2.60	.....
14	4.60	3.50	2.90	2.75	2.65	2.60	.....
15	4.60	3.45	2.90	2.75	2.65	2.55	.....
16	4.65	3.45	2.90	2.75	2.65	2.55	.....
17	4.65	3.40	2.90	2.75	2.65	2.55	.....
18	4.65	3.40	2.90	2.70	2.65	2.55	.....
19	4.55	3.35	2.90	2.75	2.65	2.55	2.45
20	4.55	3.30	3.00	2.75	2.65	2.55	.....
21	4.45	3.30	3.00	2.75	2.65	2.55	.....
22	4.40	3.25	3.00	2.75	2.65	2.55	.....
23	4.30	3.25	2.95	2.75	2.65	2.55	.....
24	4.25	3.25	2.90	2.75	2.65	2.55	.....
25	4.15	3.20	2.90	2.75	2.65	2.55	2.45
26	4.10	3.20	2.85	2.75	2.65	2.55	.....
27	4.05	3.15	2.85	2.75	2.65	2.55	.....
28	4.00	3.15	2.85	2.70	2.65	2.40	.....
29	3.90	3.15	2.85	2.70	2.60	2.55	.....
30	3.85	3.15	2.85	2.70	2.60	2.55	.....
31	.....	3.10	2.85	.....	2.60	.....	.....

Ogden River at Eden, Utah.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.48	1.67	1.70	3.11	5.50	10.30	2.35	1.85	1.61	1.61	1.62	.....
2	1.49	1.67	1.70	.....	5.90	10.20	2.25	1.80	1.60	1.60	1.63	.....
3	1.54	1.64	1.68	3.15	5.90	10.20	2.20	1.80	1.60	1.60	1.63	1.60
4	1.54	1.62	.....	.....	6.20	9.70	2.20	1.80	1.60	1.60	1.63	.....
5	1.52	1.62	1.65	.....	7.00	8.90	2.19	1.79	1.60	1.60	1.63	.....
6	1.50	1.62	.....	3.60	7.50	8.60	2.13	1.75	1.61	1.60	1.63	.....
7	1.40	1.63	.....	.....	6.80	8.00	2.15	1.73	1.61	1.60	1.63	.....
8	1.43	1.67	1.65	4.00	6.40	7.50	2.00	1.70	1.62	1.60	1.63	.....
9	1.45	1.70	.....	.....	6.70	6.90	1.90	1.69	1.64	1.60	2.45	.....
10	1.44	1.70	.....	.....	6.30	6.70	1.93	1.65	1.64	1.60	2.00	1.60
11	1.45	1.70	1.66	.....	5.80	6.00	1.90	1.63	1.65	1.60	1.83	.....
12	1.45	1.69	.....	3.80	6.20	5.50	1.89	1.63	1.65	1.60	1.80	.....
13	1.45	1.69	.....	.....	5.65	5.20	1.95	1.62	1.65	1.60	1.78	.....
14	1.45	1.67	1.65	8.50	5.45	4.90	2.00	1.60	1.65	1.60	1.77	.....
15	1.46	1.64	.....	.....	5.20	4.70	2.10	1.60	1.64	1.60	1.70	.....
16	1.48	1.63	.....	.....	4.80	4.40	2.00	1.60	1.64	1.60	1.71	1.65
17	1.54	1.61	1.67	5.30	4.85	4.10	2.00	1.60	1.63	1.60	1.73	.....
18	1.60	1.61	.....	5.20	4.65	4.00	1.95	1.60	1.60	1.60	1.77	.....
19	1.71	1.61	.....	4.80	4.60	3.80	1.90	1.57	1.60	1.60	1.76	.....
20	1.69	1.62	.....	4.50	4.50	3.50	1.85	1.64	1.60	1.60	1.75	.....
21	1.80	1.62	1.85	4.35	4.70	3.25	1.85	1.61	1.60	1.60	1.75	.....
22	2.00	1.62	.....	4.50	5.60	3.15	1.85	1.63	1.61	1.60	.....	.....
23	1.85	1.63	.....	4.40	7.30	2.90	1.85	1.63	1.63	1.60	.....	.....
24	1.80	1.63	2.80	4.50	8.60	2.70	1.85	1.63	1.62	1.60	.....	1.60
25	1.73	1.64	.....	5.20	8.50	2.55	1.85	1.63	1.61	1.60	.....	.....
26	1.73	1.64	4.50	6.20	9.20	2.55	1.85	1.62	1.61	1.60	.....	.....
27	1.71	1.65	7.50	6.50	10.00	2.88	1.80	1.62	1.60	1.61	.....	.....
28	1.70	1.70	5.70	5.60	10.50	2.48	1.78	1.61	1.60	1.62	.....	.....
29	1.68	1.70	.....	5.40	10.50	2.38	1.75	1.62	1.61	1.62	1.50	.....
30	1.68	.....	4.15	6.10	11.20	2.30	1.80	1.62	1.61	1.62	1.50	.....
31	1.67	.....	.....	.....	11.00	.....	1.90	1.61	.....	1.62	.....	2.60

Weber River at Uinta, Utah.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.60	1.70	1.70	2.10	3.40	8.75	2.00	1.86	1.30	1.40	1.60	.....
2	1.70	1.70	1.70	2.25	3.30	8.50	1.93	1.90	1.30	1.40	1.70	.....
3	1.70	1.70	1.70	2.35	3.35	7.80	1.85	1.90	1.30	1.40	1.80	.....
4	1.70	1.70	1.70	2.45	3.55	7.30	1.78	1.80	1.30	1.40	1.80	.....
5	1.70	1.70	1.70	2.55	3.90	7.05	1.71	1.70	1.30	1.40	1.80	1.70
6	1.70	1.70	1.70	2.65	4.55	6.70	1.71	1.60	1.30	1.40	1.80	.....
7	1.70	1.70	1.70	2.85	4.45	5.75	1.71	1.60	1.30	1.40	1.80	.....
8	1.70	1.70	1.70	2.95	4.40	5.95	1.71	1.50	1.30	1.40	1.90	1.70
9	1.70	1.70	1.70	3.00	4.30	6.25	1.64	1.40	1.30	1.40	2.00	.....
10	1.70	1.70	1.70	2.85	2.95	5.90	1.57	1.30	1.30	1.40	2.00	.....
11	1.70	1.70	1.70	2.65	2.85	5.50	1.49	1.20	1.30	1.40	2.00	.....
12	1.70	1.70	1.70	2.50	3.55	5.15	1.49	1.10	1.30	1.40	2.00	1.70
13	1.70	1.70	1.80	4.10	3.60	4.75	1.49	1.10	1.30	1.40	2.00	.....
14	1.70	1.70	1.90	4.40	3.35	4.65	1.71	1.00	1.30	1.40	2.00	1.60
15	1.70	1.70	1.90	4.40	2.95	4.40	1.64	1.00	1.30	1.40	1.90	.....
16	1.70	1.70	2.00	3.55	3.00	3.75	1.49	1.00	1.30	1.40	1.80	.....
17	1.70	1.70	2.15	3.10	2.80	3.19	1.49	1.00	1.30	1.40	1.70	.....
18	1.70	1.70	2.30	2.55	2.80	3.10	1.49	1.00	1.30	1.60	1.70	1.60
19	1.70	1.70	2.55	2.65	2.70	3.10	1.93	1.00	1.30	1.60	1.70	.....
20	1.70	1.70	2.75	2.70	2.70	3.01	2.00	1.00	1.30	1.60	1.70	.....
21	1.70	1.70	2.90	2.80	2.85	2.84	2.00	1.00	1.30	1.60	1.70	.....
22	1.70	1.70	3.10	2.85	2.90	2.66	2.00	1.00	1.30	1.60	1.70	.....
23	1.70	1.70	3.25	2.60	2.90	2.57	2.00	a1.30	1.30	1.60	1.70	.....
24	1.70	1.70	2.95	2.60	4.85	2.48	2.00	1.30	1.30	1.60	1.70	1.50
25	1.70	1.70	2.90	2.60	5.70	2.48	1.93	1.30	1.30	1.60	1.80	.....
26	1.70	1.70	2.75	2.75	6.50	2.66	1.93	1.30	1.30	1.60	1.80	.....
27	1.70	1.70	2.65	2.95	6.95	2.22	1.93	1.30	1.30	1.60	1.70	.....
28	1.70	1.70	2.55	3.15	7.95	2.22	1.86	1.30	1.40	1.60	1.70	.....
29	1.70	1.70	2.45	3.35	8.10	2.14	1.86	1.30	1.40	1.60	1.70	1.50
30	1.70	.....	2.45	3.50	8.20	2.07	1.86	1.30	1.40	1.60	1.70	.....
31	1.70	.....	2.40	.....	8.80	.....	1.86	1.30	.....	1.60	.....	.....

a New gage put in August 23.

Provo River at Provo Canyon, Utah.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug	Sept.	Oct.	Nov.	Dec.
1	4.20	4.30	4.20	4.50	4.80	7.30	4.50	4.40	4.20	4.30	4.30	.....
2	4.10	4.20	4.20	4.50	4.80	7.30	4.40	4.40	4.20	4.30	4.30	.....
3	4.10	4.20	4.20	4.50	4.80	7.80	4.30	4.40	4.20	4.30	4.30	.....
4	4.10	4.20	4.20	4.50	4.90	7.60	4.30	4.30	4.20	4.30	4.30	.....
5	4.20	4.20	4.20	4.50	5.00	7.30	4.30	4.30	4.20	4.30	4.30	4.40
6	4.20	4.20	4.20	4.50	5.20	6.90	4.30	4.30	4.20	4.30	4.30	.....
7	4.20	4.20	4.20	4.50	5.40	6.90	4.30	4.20	4.20	4.30	4.30	.....
8	4.20	4.20	4.20	4.50	5.40	6.90	4.20	4.20	4.20	4.30	4.60	.....
9	4.20	4.20	4.20	4.40	5.50	6.80	4.20	4.20	4.20	4.30	4.60	.....
10	4.20	4.20	4.20	4.40	5.30	6.80	4.20	4.20	4.20	4.30	4.60	.....
11	4.20	4.20	4.20	4.30	5.30	6.60	4.20	4.20	4.20	4.30	4.60	.....
12	4.20	4.20	4.20	5.30	5.20	6.50	4.20	4.20	4.20	4.30	4.50	4.40
13	4.20	4.30	4.20	5.80	5.20	6.50	4.20	4.20	4.20	4.30	4.50	.....
14	4.20	4.30	4.20	5.90	4.90	6.20	4.20	4.20	4.20	4.30	4.50	.....
15	4.20	4.30	4.30	5.80	4.70	6.00	4.30	4.20	4.20	4.30	4.40	.....
16	4.20	4.20	4.30	5.30	4.70	5.80	4.30	4.20	4.20	4.30	4.40	.....
17	4.30	4.20	4.30	4.70	4.70	5.60	4.30	4.20	4.20	4.30	4.40	.....
18	4.30	4.20	4.40	4.70	4.70	5.00	4.30	4.20	4.20	4.30	4.40	.....
19	4.40	4.20	4.40	4.60	4.70	4.80	4.20	4.20	4.20	4.30	4.40	4.40
20	4.40	4.20	4.40	4.60	4.70	4.60	4.20	4.20	4.30	4.30	4.40	.....
21	4.50	4.20	4.50	4.60	4.70	4.60	4.30	4.20	4.30	4.30	4.40	.....
22	4.50	4.20	4.60	4.60	4.70	4.90	4.90	4.20	4.30	4.30	4.50	.....
23	4.40	4.20	4.60	4.60	4.70	4.80	4.80	4.20	4.30	4.30	4.50	.....
24	4.30	4.20	4.60	4.60	5.90	4.80	4.70	4.20	4.30	4.30	4.50	.....
25	4.30	4.20	4.70	4.60	5.60	4.70	4.50	4.20	4.30	4.30	4.50	.....
26	4.30	4.20	4.70	4.70	6.00	4.60	4.50	4.20	4.30	4.30	4.50	4.40
27	4.30	4.20	4.80	4.70	6.20	4.60	4.50	4.20	4.30	4.30	4.40	.....
28	4.30	4.20	4.90	4.70	6.50	4.60	4.50	4.20	4.30	4.30	4.40	.....
29	4.30	4.20	4.60	4.70	7.00	4.60	4.50	4.20	4.30	4.30	.....	.....
30	4.30	.....	4.60	4.80	7.80	4.50	4.50	4.20	4.30	4.30	.....	.....
31	4.30	.....	4.60	.....	8.50	.....	4.50	4.20	.....	4.30	.....	.....

Portneuf River at McCammon, Idaho.

Day.	Apr.	May.	June.	July.	Day.	Apr.	May.	June.	July.	Day.	Apr.	May.	June.	July.
1	.....	3.50	4.50	3.25	12	.....	3.83	4.17	3.00	23	3.46	3.50	3.58	.....
2	.....	3.50	4.50	3.08	13	.....	3.75	4.08	2.92	24	3.50	3.83	3.58	.....
3	.....	3.50	4.46	3.08	14	3.50	3.75	4.08	3.00	25	3.50	4.00	3.54	.....
4	.....	3.58	4.42	3.00	15	3.67	3.58	4.00	3.00	26	3.50	4.08	3.50	.....
5	.....	3.63	4.50	3.00	16	3.67	3.58	4.00	3.00	27	3.46	4.17	3.46	.....
6	.....	3.83	4.42	3.00	17	3.67	3.50	4.04	3.00	28	3.58	4.25	3.42	.....
7	.....	3.92	4.42	2.92	18	3.50	3.50	4.00	3.00	29	3.58	4.25	3.33	.....
8	.....	3.83	4.25	2.92	19	3.50	3.50	4.00	.....	30	3.50	4.29	3.25	.....
9	.....	3.92	4.25	2.88	20	3.50	3.54	3.92	.....	31	.....	4.50	.....	.....
10	.....	3.92	4.25	2.88	21	3.50	3.54	3.83	.....					
11	.....	3.92	4.25	2.88	22	3.46	3.50	3.83	.....					

Malad River at Taponis, Idaho.

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1	.....	.....	.....	1.80	12	8.00	.....	.....	.....	23	8.60	.....	.....	.....
2	9.40	7.20	.....	.....	14	8.60	5.60	1.80	.....	24	.....	7.67	.....	.....
4	.....	.....	2.30	1.60	15	.....	.....	.....	1.80	25	.....	.....	.....	1.80
5	9.60	.....	.....	.....	16	8.80	.....	.....	.....	26	7.60	.....	.....	.....
7	.....	6.40	2.20	.....	17	.....	6.25	.....	.....	28	7.40	8.50	.....	.....
8	.....	.....	.....	1.70	18	.....	.....	2.00	1.80	29	.....	.....	.....	1.90
9	7.80	.....	.....	.....	19	9.60	.....	.....	.....	30	7.40	.....	.....	.....
10	.....	6.20	.....	.....	21	8.80	7.17	.....	.....	31	.....	9.00	.....	.....
11	.....	.....	2.00	1.70	22	.....	.....	.....	1.80					

Snake River at Montgomerys Ferry, Idaho.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	3.80	9.25	9.20	3.95	2.75	2.70
2	.....	3.80	9.80	8.90	3.90	2.70	2.70
3	.....	3.80	10.05	8.65	3.85	2.70	2.70
4	.....	3.80	10.25	8.50	3.70	2.70	2.70
5	3.20	4.00	10.50	8.35	3.60	2.70	2.70
6	2.95	4.10	10.75	8.15	3.50	2.70	2.70
7	2.75	4.30	11.00	7.90	3.50	2.70	2.70
8	2.70	4.85	11.00	7.65	3.40	2.70	2.70
9	2.60	5.35	10.95	7.45	3.35	2.70	2.70
10	2.65	5.40	10.65	7.20	3.25	2.65	2.70
11	2.70	5.40	10.50	6.95	3.15	2.65	2.70
12	2.80	5.40	10.70	6.75	3.10	2.70	2.70
13	2.85	5.30	11.10	6.55	3.10	2.70	2.70
14	2.90	5.20	11.45	6.50	3.10	2.70	2.70
15	3.00	5.05	11.65	6.45	3.00	2.70	2.70
16	2.90	5.00	11.75	6.55	2.90	2.70	2.70
17	3.05	4.90	11.80	6.60	2.90	2.70	2.70
18	3.20	4.85	11.85	6.50	2.80	2.70	2.70
19	3.20	4.80	11.95	6.45	2.80	2.70	2.70
20	3.15	4.70	12.10	6.25	2.80	2.70	2.70
21	2.95	4.60	12.20	6.05	2.80	2.70	2.70
22	2.85	4.50	12.25	5.75	2.80	2.70	2.70
23	2.80	4.50	12.30	5.55	2.80	2.70	2.70
24	2.80	4.90	12.10	5.35	2.80	2.70	2.70
25	2.80	5.30	11.80	5.10	2.90	2.70	.....
26	2.85	5.85	11.35	4.85	2.90	2.70	.....
27	2.90	6.45	10.90	4.75	2.80	2.70	.....
28	2.95	6.80	10.35	4.55	2.80	2.70	.....
29	3.25	7.25	9.90	4.35	2.80	2.80	.....
30	3.65	7.90	9.50	4.20	2.80	2.75	.....
31	.....	8.60	.....	4.05	2.80	.....	.....

Little Camas Creek at Little Camas Store, Idaho.

Day.	March.			April.			May.			June.			July.			August.		
	First channel, gage height.	Second channel, gage height.	Third channel, gage height.	1. Gage height.	2. Gage height.	3. Gage height.	1. Gage height.	2. Gage height.	3. Gage height.	1. Gage height.	2. Gage height.	3. Gage height.	1. Gage height.	2. Gage height.	3. Gage height.	1. Gage height.	2. Gage height.	3. Gage height.
1	....	....	....	1.20	1.30	1.00	1.60	1.50	1.30	1.70	1.90	1.30	0.70	0.60	0.40	0.60	0.30	0.30
2	....	....	....	1.10	1.20	.90	1.50	1.40	1.20	1.70	1.90	1.30	.60	.50	.30	.60	.30	.30
3	....	....	....	1.20	1.30	1.00	1.60	1.60	1.40	1.70	2.00	1.40	.60	.50	.30	.40	.20	.30
4	....	....	....	1.40	1.80	1.10	1.60	1.70	1.50	1.70	2.00	1.40	.60	.50	.30	.40	.20	.30
5	....	....	....	1.30	1.50	1.10	1.50	1.60	1.40	1.70	1.90	1.40	.60	.40	.30	.30	.20	.10
6	....	....	....	1.40	1.60	1.20	1.40	1.50	1.30	1.60	1.70	1.20	.60	.40	.30	.30	.20	.10
7	....	....	....	1.40	1.60	1.20	1.40	1.50	1.30	1.50	1.60	1.10	.70	.40	.30	.20	.10	.10
8	....	....	....	1.20	1.40	1.00	1.40	1.50	1.30	1.40	1.50	1.10	.70	.40	.30	.20	.10	.20
9	....	....	....	1.00	1.10	.80	1.40	1.50	1.30	1.40	1.50	1.10	.70	.30	.30	.10	.20	.30
10	....	....	....	1.00	1.10	.80	1.50	1.40	1.20	1.40	1.50	1.10	.70	.30	.30	.10	.20	.30
11	....	....	....	1.40	1.30	1.00	1.60	1.70	1.40	1.40	1.50	1.10	.70	.30	.30	.10	.20	.30
12	....	....	....	1.30	1.40	1.10	1.40	1.40	1.20	1.30	1.40	1.00	.70	.30	.30	.10	.20	.30
13	....	....	....	1.60	2.50	1.50	1.30	1.30	1.10	1.30	1.30	1.00	.70	.30	.30	.10	.20	.30
14	....	....	....	1.30	2.00	1.20	1.30	1.20	1.00	1.30	1.30	1.00	.70	.30	.30	.10	.20	.30
15	....	....	....	1.20	1.80	1.30	1.30	1.20	1.00	1.20	1.30	1.00	.70	.30	.20	.10	.20	.30
16	....	....	....	1.20	1.60	1.20	1.30	1.20	1.00	1.10	1.20	.90	.70	.30	.20	....	....	.....
17	....	....	....	1.30	1.80	1.30	1.40	1.20	1.00	1.10	1.20	.90	.70	.30	.20	....	....	.....
18	....	....	....	1.20	1.50	1.20	1.40	1.20	1.00	.90	1.10	.80	.70	.30	.20	....	....	.....
19	....	....	....	1.30	1.40	1.20	1.40	1.20	1.00	.90	1.10	.80	.70	.30	.20	....	....	.....
20	....	....	....	1.40	1.40	1.30	1.40	1.20	.90	.90	1.00	.70	.70	.30	.30	....	....	.....
21	....	....	....	1.40	1.40	1.20	1.40	1.20	.90	.90	.90	.80	.70	.30	.30	....	....	.....
22	....	....	....	1.40	1.40	1.30	1.40	1.30	1.00	.90	.90	.80	.70	.30	.30	....	....	.....
23	....	....	....	1.50	1.30	1.10	1.50	1.40	1.10	.90	.90	.80	.70	.30	.30	....	....	.....
24	....	....	....	1.50	1.30	1.10	1.60	1.50	1.30	.90	.90	.80	.60	.30	.30	....	....	.....
25	....	....	....	1.50	1.30	1.10	1.60	1.70	1.30	.80	.80	.70	.60	.30	.30	....	....	.....
26	....	....	....	1.50	1.40	1.30	1.70	1.70	1.30	.80	.80	.70	.60	.30	.30	....	....	.....
27	....	....	....	1.60	1.50	1.40	1.70	1.70	1.30	.80	.80	.70	.60	.30	.30	....	....	.....
28	....	....	....	1.50	1.40	1.20	1.60	1.70	1.20	.70	.70	.50	.60	.30	.30	....	....	.....
29	2.50	2.70	2.50	1.50	1.50	1.30	1.60	1.80	1.30	.70	.60	.40	.60	.30	.30	....	....	.....
30	2.40	2.60	2.40	1.50	1.40	1.20	1.80	2.10	1.30	.70	.60	.40	.60	.30	.30	....	....	.....
31	2.30	2.40	2.30	.....	.....	.....	1.80	1.90	1.30	.....	.....	....	.60	.30	.30	....	....	.....

Little Wood River at Taponis, Idaho.

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1	.....	.....	.....	1.50	11	.....	.....	1.20	1.33	22	.....	.....	.....	2.58
2	6.90	.....	.....	.....	12	6.40	.....	.....	.....	23	6.40	.....	.....	.....
3	.....	4.40	.....	.....	14	6.40	4.30	1.20	.....	24	.....	5.67	.....	.....
4	.....	.....	1.20	2.08	15	.....	.....	.....	2.17	25	.....	.....	.....	2.67
5	7.10	.....	.....	.....	16	6.70	.....	.....	.....	26	5.20	.....	.....	.....
7	.....	3.90	1.00	.....	17	.....	4.50	.....	.....	28	5.30	6.33	.....	.....
8	.....	.....	.....	1.33	18	.....	.....	1.20	2.33	29	.....	.....	.....	2.75
9	6.40	.....	.....	.....	19	6.90	.....	.....	.....	30	4.10	.....	.....	.....
10	.....	4.30	.....	.....	21	6.70	5.00	.....	.....	31	.....	7.17	.....	.....

Bruneau River at Owyhee, Idaho.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	Day.	Jan.	Feb.	Mar.	Apr.	May.	June.
1	1.65	1.75	1.75	2.45	2.90	6.40	17	1.65	1.60	1.75	3.20	2.80	4.70
2	1.65	1.75	1.75	2.40	2.90	6.70	18	1.70	1.60	1.75	3.00	2.70	4.60
3	1.65	1.75	1.75	2.40	2.95	6.00	19	1.70	1.65	1.75	2.90	2.65	4.60
4	1.65	1.75	1.75	2.35	2.90	5.90	20	1.75	1.65	1.80	2.85	2.60	4.30
5	1.60	1.75	1.75	2.35	2.90	5.35	21	1.75	1.70	1.80	2.75	2.60	4.20
6	1.60	1.75	1.80	2.35	3.30	5.00	22	1.75	1.70	1.95	2.75	2.60	4.00
7	1.60	1.75	1.80	2.40	3.25	4.95	23	1.75	1.70	2.40	2.90	2.60	3.80
8	1.65	1.75	1.80	2.55	3.20	4.80	24	1.75	1.70	2.45	2.90	2.90	3.70
9	1.65	1.70	1.80	2.60	3.15	4.70	25	1.75	1.70	2.75	2.90	2.95	3.60
10	1.65	1.70	1.80	2.65	3.00	5.00	26	1.75	1.70	3.20	2.90	3.20	3.45
11	1.65	1.70	1.75	2.65	3.00	5.20	27	1.75	1.70	3.35	3.00	3.80	3.35
12	1.65	1.70	1.75	2.55	3.00	4.90	28	1.75	1.70	3.55	3.15	4.00	3.30
13	1.65	1.70	1.75	2.40	3.15	4.65	29	1.75	1.70	3.35	3.00	4.50	3.20
14	1.65	1.70	1.75	2.80	3.00	4.60	30	1.75	.....	3.00	2.90	5.30	3.15
15	1.65	1.70	1.75	3.85	2.95	4.65	31	1.75	.....	2.85	.....	6.00	.....
16	1.65	1.70	1.75	3.60	2.95	4.60							

Boise River at Boise, Idaho.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.80	2.70	2.60	4.40	5.30	9.00	6.30	3.30	2.20	1.70	1.90	1.20
2	2.00	2.40	2.40	3.90	5.00	9.00	6.80	3.00	2.20	1.80	2.00	1.10
3	1.40	2.40	2.40	3.80	5.30	9.60	7.00	3.30	2.00	1.60	1.90	1.10
4	1.40	2.00	2.30	3.80	6.00	9.30	7.00	2.90	1.90	1.60	1.90	1.40
5	1.40	2.00	2.40	3.90	6.00	9.00	6.80	2.80	1.80	1.70	1.70	2.00
6	1.40	1.80	2.00	3.90	5.60	8.70	6.70	2.80	1.80	1.60	1.70	2.40
7	1.40	1.80	2.00	4.60	5.70	8.70	6.60	2.70	1.80	1.80	1.50	2.40
8	1.80	2.00	2.20	4.80	5.80	8.80	6.50	2.70	1.70	1.70	1.90	2.60
9	1.80	2.00	2.40	4.40	5.60	8.60	6.30	2.70	1.70	1.60	2.60	2.60
10	1.80	2.00	2.20	5.00	5.40	8.80	6.20	2.60	1.70	1.60	2.30	2.40
11	1.80	1.90	2.30	4.50	5.50	8.50	6.10	2.60	1.80	1.70	2.00	2.00
12	2.00	2.00	2.30	4.50	5.40	8.50	6.10	2.40	1.80	1.60	1.90	2.60
13	1.80	2.00	2.40	5.70	5.20	9.30	5.90	2.30	1.70	1.60	1.90	2.70
14	1.40	1.90	2.40	6.70	5.00	10.00	5.80	2.20	1.80	1.60	1.90	2.80
15	1.40	2.00	2.40	5.80	5.00	9.60	5.60	2.20	1.80	1.70	2.00	2.50
16	1.20	2.00	2.40	5.50	5.00	9.60	5.40	2.20	1.80	1.60	1.90	2.50
17	1.90	1.90	2.30	5.40	4.90	9.60	5.00	2.20	1.70	1.60	1.90	2.40
18	2.30	1.90	2.40	5.00	4.80	9.50	4.80	2.00	1.70	1.70	2.00	2.40
19	2.40	2.00	2.40	4.80	4.70	9.40	4.60	2.00	1.60	1.70	2.60	2.20
20	2.50	2.00	2.70	4.50	4.70	9.00	4.00	1.90	1.70	1.60	2.80	2.20
21	3.00	2.00	3.50	4.40	4.60	9.00	3.60	1.90	1.70	1.60	2.40	2.00
22	3.00	2.10	3.90	5.00	5.00	8.50	3.00	1.80	1.60	1.70	2.70	2.00
23	3.00	2.10	4.00	5.10	5.80	8.00	3.60	1.90	1.70	1.70	2.70	1.90
24	2.40	2.10	4.60	5.10	6.70	7.50	4.00	1.90	1.90	1.70	2.90	1.90
25	2.30	2.20	4.60	5.40	7.00	7.30	4.00	1.80	2.00	1.60	2.60	1.80
26	2.60	2.20	5.60	5.80	7.40	7.30	3.40	1.90	.....	1.60	2.40	1.80
27	2.80	2.30	6.10	5.30	7.40	9.00	3.20	1.80	1.90	1.80	2.00	2.00
28	2.90	2.90	5.70	5.20	8.00	6.80	3.00	1.90	1.90	1.80	1.60	2.00
29	2.80	3.00	5.50	5.30	8.10	6.40	3.40	1.90	1.80	1.80	1.40	2.10
30	2.80	.....	4.60	5.10	8.60	6.40	3.40	2.00	1.70	1.60	1.40	2.10
31	2.70	.....	4.50	.....	9.50	.....	3.30	2.20	.....	1.90	.....	2.10

Boise River at Caldwell, Idaho.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	5.75	6.40	11.00	8.20	4.40	3.65
2	.....	5.60	6.50	11.00	7.80	4.40	3.60
3	.....	5.55	6.40	11.30	7.70	4.30	3.60
4	4.40	5.50	7.00	11.00	7.60	4.25	3.55
5	4.40	5.60	7.60	10.00	7.40	4.20	3.50
6	4.30	5.80	7.40	9.90	7.40	4.20	3.50
7	4.30	5.90	7.10	9.50	7.30	4.15	3.45
8	4.30	6.00	7.00	9.20	7.20	4.10	3.45
9	4.30	6.00	7.00	9.90	7.00	4.10	3.45
10	4.35	5.90	6.90	10.20	6.95	4.00	3.45
11	4.40	5.80	7.00	9.80	6.80	3.90	3.45
12	4.40	5.90	6.80	9.60	6.70	3.90	3.45
13	4.40	6.30	6.60	9.80	6.75	3.85	3.50
14	4.50	8.00	6.50	10.00	6.60	3.80	3.50
15	4.45	7.40	6.40	9.90	6.50	3.70	3.45
16	4.45	6.90	6.30	10.00	6.30	3.70	3.40
17	4.50	6.60	6.40	10.00	6.10	3.65	3.40
18	4.55	6.50	6.20	10.30	5.90	3.60	3.40
19	4.60	6.20	6.10	10.00	5.70	3.60	3.45
20	4.85	6.20	6.00	9.80	5.40	3.55	3.40
21	5.40	6.15	6.00	9.40	5.30	3.50	3.45
22	5.70	6.10	6.10	9.00	5.20	3.50	3.45
23	5.75	6.15	6.80	8.60	5.10	3.50	3.50
24	6.00	6.30	7.60	8.40	5.00	3.45	3.65
25	7.10	6.60	8.00	8.30	4.90	3.40	3.70
26	7.10	6.80	8.50	8.10	4.80	3.35	3.65
27	7.70	6.70	8.60	8.00	4.70	3.30	3.60
28	7.30	6.60	8.90	8.20	4.70	3.25	3.60
29	6.70	6.50	9.10	8.10	4.60	3.20	3.55
30	6.35	6.55	10.00	8.00	4.50	3.20	3.50
31	5.90	.....	11.00	.....	4.50	3.30	.....

Owyhee River at Nyssa, Oregon.

Day.	Jan.	Feb.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	1.30	1.60	.....	3.65	5.75	2.25	1.05	1.30	1.10	.....
2	1.30	1.50	.....	3.60	5.45	2.15	1.00	1.30	1.10	.....
3	1.30	1.50	.....	3.85	5.00	2.05	1.00	1.30	1.10	.....
4	1.30	1.40	.....	4.05	4.70	1.95	1.00	1.20	.....	.....
5	1.40	1.40	.....	4.35	4.55	1.90	1.00	1.20	.....	.....
6	1.40	1.50	.....	4.45	4.45	1.85	1.00	1.10	.....	.....
7	1.40	1.50	.....	4.65	4.35	1.80	1.00	1.10	.....	.....
8	1.40	1.50	.....	4.80	4.30	1.75	1.00	1.00	.....	.....
9	1.40	1.40	.....	4.90	4.25	1.70	.95	1.00	.....	.....
10	1.40	1.40	.....	4.80	4.15	1.65	.95	.90	.....	.....
11	1.40	1.40	.....	4.80	4.15	1.60	.95	.90	.....	.....
12	1.40	1.40	.....	4.70	4.05	1.50	.95	.90	.....	.....
13	1.40	1.35	.....	4.65	3.95	1.45	.95	.95	.....	.....
14	1.55	1.30	.....	4.60	3.55	1.40	.95	.95	.....	.....
15	1.75	1.30	.....	4.55	3.45	1.40	.95	1.00	.....	.....
16	2.50	1.30	.....	4.50	3.35	1.35	.90	1.00	.....	.....
17	5.65	1.30	.....	4.40	3.30	1.30	.90	1.00	.....	1.20
18	3.80	1.30	.....	4.40	3.25	1.25	.90	1.00	.....	1.20
19	3.35	1.30	.....	4.55	3.15	1.20	.90	1.00	.....	1.20
20	3.05	1.40	.....	4.60	3.05	1.20	.90	1.00	.....	1.20
21	2.75	1.40	.....	4.65	2.95	1.20	.90	1.00	.....	1.20
22	2.55	1.40	.....	4.75	2.90	1.10	.90	1.00	.....	1.20
23	2.45	1.50	.....	4.85	2.85	1.10	1.00	.95	.....	1.20
24	2.40	1.50	.....	5.05	2.80	1.10	1.00	.95	.....	.....
25	2.35	1.55	.....	5.25	2.75	1.00	1.10	1.00	.....	.....
26	2.05	1.60	3.40	5.45	2.70	1.20	1.10	1.00	.....	.....
27	1.85	1.60	3.45	5.65	2.65	1.20	1.20	1.00	.....	.....
28	1.80	1.60	3.55	5.85	2.45	1.15	1.20	1.00	.....	.....
29	1.75	1.60	3.65	5.95	2.40	1.10	1.30	1.00	.....	.....
30	1.70	.....	3.70	6.05	2.35	1.10	1.40	1.00	.....	.....
31	1.60	.....	.....	6.00	.....	1.10	1.40	.....	.....	.....

Malheur River at Vale, Oregon.

Day.	Jan. a	Feb.	Apr.	May.	June.	July.	Aug.	Sept.
1	1.70	2.55	.....	3.00	4.30	2.45	1.00	1.60
2	1.75	2.65	.....	3.00	4.35	2.35	.95	1.45
3	1.80	2.70	.....	3.05	4.50	2.30	.90	1.20
4	1.90	2.60	.....	3.10	4.50	2.25	.90	1.10
5	1.90	2.60	.....	3.85	4.45	2.15	.90	1.10
6	1.90	2.50	.....	4.90	4.30	2.10	.85	1.10
7	1.85	2.50	.....	4.65	4.25	2.10	.75	1.10
8	1.90	2.40	.....	4.05	4.25	2.05	.70	1.10
9	1.85	2.35	.....	3.85	4.10	1.95	.70	1.10
10	1.85	2.25	.....	3.80	4.05	1.90	.71	1.10
11	1.70	2.20	.....	3.70	3.90	1.85	.72	1.10
12	1.70	2.10	.....	3.70	3.75	1.80	.72	1.10
13	1.70	2.00	.....	3.75	3.70	1.85	.71	1.10
14	1.70	2.00	.....	3.65	3.60	1.90	.71	1.10
15	1.70	2.00	.....	3.45	3.50	1.95	.71	1.10
16	1.75	2.00	.....	3.30	3.50	1.90	.70	1.10
17	5.09	2.00	.....	3.30	3.50	1.90	.70	1.10
18	.....	2.05	.....	3.30	3.40	1.65	.70	1.10
19	.....	2.10	.....	3.30	3.35	1.60	.70	1.10
20	.....	2.10	.....	3.20	3.40	1.50	.70	1.15
21	.....	2.00	.....	3.15	3.35	1.50	.70	1.20
22	.....	1.95	.....	3.10	3.30	1.45	.70	1.20
23	.....	2.05	.....	3.10	3.25	1.40	.70	1.20
24	.....	2.20	.....	3.25	3.15	1.40	.70	1.20
25	3.20	2.30	.....	3.55	3.05	1.30	.69	1.20
26	3.10	2.15	2.90	3.75	3.40	1.30	.68	1.20
27	2.90	2.20	3.00	3.90	3.35	1.25	.68	1.25
28	2.75	2.30	3.00	4.00	2.75	1.20	.70	1.25
29	2.60	2.95	3.00	4.10	2.65	1.15	.70	1.25
30	2.55	.....	3.00	4.20	2.55	1.10	.70	1.25
31	2.65	.....	.....	4.20	.....	1.00	2.20	.....

a January 16 to 25 gage broken; no readings.

Payette River at Payette, Idaho.

Day.	May.	June.	July.	Aug.	Sept.	Day.	May.	June.	July.	Aug.	Sept.
1	.....	8.20	7.50	2.20	1.90	17	3.70	8.90	4.90	1.60	1.10
2	.....	8.30	7.40	2.20	1.80	18	3.60	9.20	4.30	1.60	1.10
3	.....	9.10	7.20	2.10	1.70	19	3.60	9.20	3.90	1.50	1.00
4	.....	9.30	6.80	2.10	1.40	20	3.30	9.10	3.70	1.50	1.00
5	.....	9.10	6.80	2.10	1.30	21	3.40	9.00	3.50	1.40	1.00
6	.....	9.20	6.50	2.00	1.30	22	4.20	8.80	3.30	1.40	1.00
7	.....	8.60	6.40	2.00	1.20	23	5.40	7.60	3.10	1.40	1.10
8	.....	8.40	6.20	1.90	1.20	24	5.40	7.90	2.90	1.30	1.10
9	.....	8.70	6.00	1.90	1.10	25	5.60	7.50	2.80	1.30	1.10
10	.....	8.90	5.70	1.80	1.10	26	5.90	7.40	2.70	1.20	1.10
11	.....	8.50	5.70	1.80	1.10	27	6.10	7.40	2.60	1.20	1.00
12	4.20	8.40	5.50	1.80	1.10	28	6.50	7.20	2.50	1.10	.90
13	4.30	8.30	6.20	1.80	1.10	29	6.90	7.40	2.50	1.10	.90
14	4.00	8.70	5.90	1.70	1.10	30	7.20	7.50	2.40	1.20	.90
15	3.70	8.80	5.50	1.70	1.10	31	7.70	.....	2.30	1.30	.....
16	3.79	8.80	5.30	1.70	1.10						

Yakima River at Kiona, Washington.

Day.	Jan.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Jan.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.30	.....	4.73	4.08	4.24	5.95	17	.....	5.10	4.48	4.00	15.18	9.20
2	5.35	6.10	4.73	4.05	4.35	6.10	18	.....	5.05	4.50	3.96	16.07	8.70
3	5.20	6.15	4.70	4.05	4.40	6.50	19	.....	5.00	4.55	3.94	13.35	8.52
4	5.10	6.10	4.70	4.10	4.46	7.10	20	.....	4.95	4.45	3.93	10.91	8.43
5	5.35	6.05	4.70	4.10	4.47	8.90	21	.....	4.90	4.35	3.92	9.50	8.31
6	5.40	6.00	4.68	4.05	4.51	9.80	22	.....	4.85	4.30	3.89	9.20	8.30
7	5.55	5.90	4.65	4.08	4.52	11.45	23	6.35	4.80	4.30	3.87	8.30	8.21
8	5.90	5.80	4.65	4.10	4.52	11.55	24	6.15	4.75	4.25	3.87	7.93	8.03
9	6.70	5.70	4.63	4.08	4.56	.....	25	6.05	4.75	4.20	3.94	7.62	7.90
10	8.20	5.60	4.55	4.05	5.80	11.30	26	.....	4.70	4.20	3.91	7.23	7.70
11	8.80	5.60	4.55	4.08	5.80	10.80	27	.....	4.70	4.20	3.93	6.65	7.55
12	8.80	5.50	4.50	4.04	5.72	10.60	28	.....	4.70	4.18	3.88	5.93	7.45
13	8.00	5.35	4.50	4.00	5.60	10.65	29	.....	4.70	4.15	3.94	5.95	7.35
14	7.60	5.30	4.48	4.00	5.60	10.70	30	.....	4.70	4.13	a	5.95	7.15
15	7.15	5.20	4.50	4.01	8.68	10.07	31	.....	4.70	.....	3.94	.....	7.05
16	.....	5.15	4.50	3.95	11.91	9.50							

a No observation.

Weiser River at Weiser, Idaho.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	2.30	4.00	3.80	4.30	4.10	7.10	4.90	2.00	1.80	1.80
2	2.30	3.70	3.50	4.00	5.20	7.10	4.70	2.00	1.80	1.80
3	2.30	3.00	3.20	3.80	5.10	7.10	4.60	2.00	1.80	1.70
4	2.30	3.20	3.00	3.70	8.30	7.40	4.40	2.00	1.90	1.70
5	2.30	3.10	3.00	3.70	9.20	7.00	4.20	2.00	1.90	1.70
6	2.30	3.00	2.90	3.80	9.10	7.90	4.00	2.00	1.90	1.70
7	2.40	2.90	2.90	4.10	8.50	8.90	3.80	2.00	1.90	1.70
8	2.40	2.80	3.00	4.50	7.40	7.60	3.60	2.00	1.90	1.70
9	2.40	2.70	3.30	4.70	6.70	6.70	3.50	2.00	1.90	1.70
10	2.30	2.60	3.70	4.50	5.90	6.70	3.40	1.90	1.90	1.70
11	2.30	2.60	4.00	4.30	6.00	6.60	3.30	1.90	1.90	1.70
12	2.30	2.50	3.80	4.10	6.40	6.60	3.20	1.90	1.90	1.70
13	2.30	2.50	3.80	4.60	5.50	6.50	3.10	1.90	2.00	1.70
14	2.30	2.50	3.70	4.50	5.00	6.40	3.00	1.90	2.00	1.70
15	2.30	2.50	3.50	5.20	4.70	6.40	2.90	1.80	2.00	1.70
16	2.50	2.60	3.40	4.80	4.60	6.40	2.80	1.80	2.00	1.70
17	5.10	2.60	3.30	4.50	4.70	6.40	2.70	1.80	2.00	1.70
18	5.50	2.70	3.30	4.10	5.20	6.50	2.60	1.80	2.00	.....
19	6.50	2.70	3.40	4.00	4.70	6.60	2.50	1.80	2.00	.....
20	7.60	2.70	3.80	3.90	4.60	6.40	2.40	1.80	1.90	.....
21	8.30	2.70	4.60	3.80	4.60	6.20	2.40	1.90	1.90	.....
22	7.40	2.80	4.70	3.70	4.70	5.90	2.30	1.80	1.90	.....
23	5.80	2.90	4.70	3.80	5.10	5.80	2.30	1.80	1.90	.....
24	4.50	2.90	5.20	3.90	5.60	5.60	2.20	1.80	1.80	.....
25	3.80	3.00	6.00	4.10	6.10	5.40	2.20	1.80	1.80	.....
26	3.80	3.20	6.00	4.40	6.10	5.20	2.20	1.80	1.80	.....
27	4.00	4.00	6.50	4.70	6.10	4.90	2.10	1.80	1.80	.....
28	4.40	4.45	6.20	4.90	6.20	5.20	2.10	1.80	1.80	.....
29	6.40	4.10	5.60	4.50	6.20	5.30	2.10	1.80	1.80	.....
30	5.70	.....	5.00	4.20	6.60	5.20	2.10	1.80	1.80	.....
31	4.50	.....	4.60	.....	6.90	.....	2.00	1.80	.....	.....

Natches River at North Yakima, Washington.

Day.	Jan.	Feb.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.70	1.90	.....	3.25	1.50	1.10	1.50	3.60
2	1.60	.....	.....	3.10	1.40	1.20	1.40	3.80
3	1.60	1.90	.....	3.00	1.40	1.20	1.30	4.00
4	1.60	1.90	.....	2.90	1.40	1.20	1.20	4.50
5	.....	1.90	.....	3.00	1.40	1.10	1.10	5.00
6	2.00	2.00	.....	2.85	1.30	.90	1.00	4.90
7	2.90	2.00	.....	2.80	1.30	.89	1.20	4.70
8	3.20	1.90	.....	2.70	1.30	.88	2.20	4.50
9	3.90	.....	.....	2.65	1.30	.87	2.50	4.30
10	4.10	1.90	.....	2.45	1.25	.86	2.40	4.10
11	3.80	1.90	.....	2.35	1.20	.85	2.30	4.00
12	.....	1.90	.....	2.20	1.30	.84	2.15	3.90
13	3.10	1.90	.....	2.10	1.30	.83	2.00	3.70
14	2.90	2.00	.....	2.05	1.35	.82	4.25	3.60
15	2.80	1.90	.....	2.00	1.50	.81	8.00	3.50
16	2.80	.....	.....	1.90	1.40	.80	7.75	3.50
17	2.70	2.10	.....	1.80	1.30	.79	6.25	3.40
18	2.70	2.10	.....	1.80	1.30	.72	5.25	3.40
19	.....	2.70	.....	1.70	1.20	.74	4.70	3.30
20	2.60	2.80	.....	1.70	1.20	.76	4.30	3.30
21	2.40	2.90	.....	1.60	1.20	.76	4.00	3.30
22	2.30	3.20	.....	1.60	1.25	.60	3.80	3.20
23	2.20	.....	.....	1.50	1.30	.60	3.70	3.20
24	2.20	3.20	.....	1.50	1.20	.60	3.60	3.20
25	2.10	3.90	.....	1.50	1.10	.50	3.50	3.10
26	.....	5.60	.....	1.50	.90	.50	3.35	3.10
27	2.20	6.20	.....	1.50	.90	.60	3.15	3.10
28	2.20	5.80	3.35	1.50	.90	.75	3.00	3.00
29	2.20	5.80	3.25	1.50	.90	.95	3.20	3.00
30	1.90	.....	3.10	1.50	1.10	1.15	3.40	3.00
31	1.90	.....	3.15	1.50	.....	1.40	.....	3.00

Yakima River at Yakima, Washington.

Day.	Jan.	Feb.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.75	4.70	5.80	4.80	4.50	4.50	6.60
2	4.70	.....	5.80	4.80	4.50	4.50	7.60
3	4.70	4.70	5.70	4.80	4.50	4.50	8.20
4	4.70	4.70	5.70	4.80	4.50	4.60	7.70
5	.....	4.80	5.60	4.80	4.50	4.90	6.60
6	4.80	4.90	5.60	4.80	4.50	5.00	6.70
7	5.10	4.90	5.50	4.80	4.50	5.30	6.80
8	5.50	4.85	5.50	4.80	4.50	5.60	6.90
9	6.50	.....	5.50	4.80	4.40	5.80	8.00
10	7.20	4.80	5.40	4.80	4.40	5.90	8.20
11	6.80	4.80	5.40	4.70	4.40	5.70	8.60
12	.....	4.80	5.30	4.70	4.40	5.70	8.40
13	6.40	4.90	5.30	4.70	4.40	5.80	8.20
14	6.10	5.00	5.20	4.70	4.40	5.80	8.00
15	5.90	5.00	5.20	4.70	4.40	13.00	7.60
16	5.70	.....	5.10	4.70	4.40	15.00	7.40
17	5.60	5.20	5.10	4.70	4.40	14.00	7.10
18	5.50	5.30	5.10	4.70	4.40	12.00	6.80
19	.....	5.35	5.00	4.70	4.40	9.00	6.20
20	5.40	5.40	5.00	4.70	4.40	8.00	6.10
21	5.30	5.40	5.00	4.70	4.40	7.00	6.10
22	5.20	5.40	4.90	4.65	4.40	6.80	6.00
23	5.10	.....	4.90	4.60	4.40	6.60	6.00
24	5.10	5.60	4.90	4.60	4.40	6.40	5.90
25	5.05	6.20	4.90	4.60	4.40	6.20	5.90
26	.....	6.70	4.80	4.50	4.40	6.10	5.80
27	5.00	7.80	4.80	4.50	4.40	6.00	5.80
28	4.90	7.70	4.80	4.50	4.40	6.00	5.70
29	4.85	7.40	.....	4.50	4.40	6.00	5.70
30	4.80	.....	.....	4.50	4.40	6.00	5.60
31	4.75	.....	.....	.....	4.50	.....	5.60

Spokane River at dam of the Washington Water Power Company, Spokane, Washington, for 1891.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.08	5.00	3.83	1.50	0.33	1.00	0.50	2.75	3.83
2	.....	2.08	5.00	3.67	1.58	.25	1.00	.50	2.83	4.00
3	.....	2.17	4.92	3.50	1.58	.25	1.00	.50	3.00	4.00
4	.....	2.17	4.67	3.33	1.50	.25	1.00	.50	3.17	3.75
5	.....	2.17	4.50	3.17	1.50	.17	.92	.50	3.33	3.83
6	.....	2.17	4.50	3.17	1.50	.17	.92	.50	3.33	3.83
7	.....	2.17	4.67	3.00	1.33	.17	.92	.50	3.42	3.83
8	.....	2.50	4.83	3.00	1.33	.08	.92	.50	3.42	3.83
9	.....	2.75	5.00	2.92	1.25	.08	.83	.50	3.50	3.83
10	.....	2.92	5.00	2.83	1.25	.08	.83	.50	3.50	3.83
11	.....	2.92	5.25	2.75	1.25	.08	.83	.50	3.50	3.83
12	.....	2.92	5.00	2.67	1.25	.00	.83	.50	3.50	3.75
13	.....	3.17	5.00	2.50	1.17	.00	.83	.50	3.58	3.75
14	.....	3.33	5.00	2.50	1.17	1.33	.75	.50	3.58	3.75
15	.....	3.50	5.00	2.50	1.17	1.33	.75	.50	3.67	3.75
16	.....	3.75	5.17	2.42	1.17	1.33	.75	.50	3.67	3.75
17	.....	3.92	5.17	2.33	1.08	1.33	.75	.50	3.67	3.75
18	.....	4.08	5.25	2.25	1.00	1.33	.75	.50	3.75	3.83
19	.....	4.50	5.25	2.17	1.00	1.33	.67	1.08	3.75	3.83
20	.....	4.92	5.17	2.08	1.00	1.25	.67	2.67	3.75	3.83
21	.....	4.50	5.08	2.00	.92	1.25	.67	2.67	3.83	3.83
22	0.58	4.58	5.00	2.00	.83	1.25	.58	2.67	3.83	3.83
23	.92	4.67	4.83	1.92	.83	1.25	.58	2.67	3.83	3.83
24	1.25	4.83	4.83	1.92	.75	1.17	.58	2.67	3.83	3.83
25	1.42	4.83	4.50	1.83	.67	1.17	.58	2.67	3.83	3.83
26	1.58	4.83	4.42	1.75	.67	1.17	.50	2.67	3.83	3.83
27	1.75	4.83	4.25	1.67	.67	1.17	.50	2.67	3.83	3.83
28	1.92	4.83	4.00	1.67	.50	1.08	.50	2.67	3.83	3.83
29	2.00	4.83	4.00	1.67	.42	1.08	.50	2.67	3.83	3.83
30	2.08	5.00	4.00	1.67	.42	1.08	.50	2.67	3.83	3.83
31	2.08	.....	3.83	.....	.33	1.08	.....	2.75	.....	3.83

March 22, waste gates almost entirely closed. April 21, waste gates opened, which lowered the water about 1 foot. August 14, waste gates partly closed, one open about 2 feet 6 inches, the other, 3 feet 6 inches. October 19, waste gates further closed, one open about 8 inches, the other 1 foot. October 20, flashboards put on dam about three-fourths of the way across. December 4, about one-third of the flashboards were carried out.

Spokane River at dam of the Washington Water Power Company, Spokane, Washington, for 1892.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.83	3.33	3.08	4.58	4.42	8.00	4.33	1.58	0.92	3.00	3.00	4.00
2	3.67	3.17	3.17	4.42	4.42	8.00	4.25	2.33	.92	3.00	3.00	4.00
3	3.67	3.17	3.25	4.33	4.42	8.00	4.17	2.33	.92	3.00	3.00	4.08
4	3.67	3.17	3.33	4.08	4.42	7.92	4.08	2.17	.83	3.00	3.00	4.08
5	3.67	3.17	3.42	3.92	4.50	7.83	4.00	2.08	.83	3.00	3.00	4.17
6	3.67	3.17	3.50	3.83	4.58	7.67	3.92	2.00	.75	3.00	3.00	4.17
7	3.67	3.17	3.50	3.75	4.67	7.58	3.83	1.92	.75	3.00	3.00	4.25
8	3.67	3.17	3.50	3.75	4.75	7.42	3.75	1.83	.75	3.00	3.00	4.25
9	3.67	3.17	3.58	3.75	4.83	7.25	3.67	1.75	.67	3.00	3.00	4.25
10	3.67	3.17	3.67	3.75	4.92	7.00	3.58	1.67	.67	3.00	3.00	4.25
11	3.50	3.17	3.83	3.75	5.08	6.75	3.50	1.67	.67	3.00	3.00	4.25
12	3.50	3.25	4.00	3.75	5.33	6.67	3.33	1.58	.58	3.00	3.00	4.25
13	3.50	3.25	4.33	3.75	5.58	6.58	3.25	1.58	.50	3.00	3.00	4.25
14	3.50	3.25	4.67	3.83	5.75	6.50	3.17	1.50	.42	3.00	3.00	4.25
15	3.50	3.25	4.92	3.92	5.92	6.33	3.08	1.50	.33	3.00	3.00	4.17
16	3.50	3.25	5.17	4.00	6.00	6.25	3.00	1.50	.25	3.00	3.08	4.17
17	3.50	3.25	5.33	4.08	6.08	6.08	2.92	1.42	.00	3.00	3.17	4.17
18	3.50	3.25	5.50	4.17	6.17	6.00	2.83	1.42	.00	3.00	3.17	4.08
19	3.50	3.25	5.67	4.25	6.25	5.83	2.75	1.42	3.00	3.00	3.25	4.08
20	3.50	3.25	5.75	4.25	6.33	5.67	2.67	1.33	3.00	3.00	3.25	4.00
21	3.50	3.25	5.75	4.25	6.42	5.50	2.58	1.33	3.00	3.00	3.33	3.92
22	3.50	3.25	5.75	4.25	6.58	5.33	2.50	1.33	3.00	3.00	3.33	3.92
23	3.50	3.33	5.67	4.25	6.83	5.25	2.33	1.25	3.00	3.00	3.42	3.83
24	3.33	3.50	4.75	4.25	7.00	5.08	2.17	1.25	3.00	3.00	3.50	3.83
25	3.33	3.75	4.83	4.25	7.33	5.00	2.00	1.17	3.00	3.00	3.58	3.83
26	3.33	3.92	4.83	4.33	7.67	4.83	1.83	1.17	3.00	3.00	3.67	3.92
27	3.33	4.00	4.83	4.33	7.75	4.75	1.75	1.08	3.00	3.00	3.75	3.92
28	3.33	3.75	4.83	4.33	7.92	4.67	1.67	1.08	3.00	3.00	3.83	3.92
29	3.33	3.00	4.83	4.33	8.00	4.58	1.58	1.00	3.00	3.00	3.92	4.00
30	3.33	.....	4.83	4.42	8.00	4.50	1.58	1.00	3.00	3.00	3.92	4.00
31	3.33	.....	4.75	.....	8.00	.....	1.58	1.00	3.00	3.00	.....	4.08

February 28, part of the flashboards taken out. February 29, balance taken out. March 24, waste gates opened full. August 2, one waste gate partly closed, leaving opening 3 feet 6 inches; openings partly closed with drift logs. September 17, logs removed from waste gates. September 19, waste gates closed and flashboards put on dam.

Spokane River at dam of the Washington Water Power Company, Spokane, Washington, for 1893.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.08	3.92	3.58	3.50	6.17	8.25	5.25	1.83	0.33	3.25	5.00	4.92
2	4.17	3.83	3.58	3.75	6.33	8.25	5.17	1.75	.33	3.33	5.00	4.92
3	4.17	3.83	3.58	4.08	6.50	8.25	5.00	1.75	.25	3.42	4.92	4.83
4	4.25	3.83	3.58	4.33	6.67	8.25	5.00	1.67	.25	3.50	4.83	4.83
5	4.33	3.75	3.58	4.67	6.75	8.25	4.92	1.67	.25	3.58	4.83	4.83
6	4.42	3.75	3.58	4.00	6.83	8.00	4.83	1.67	.17	3.67	4.92	4.83
7	4.50	3.75	3.58	4.42	6.92	8.00	4.75	1.58	.08	3.83	5.17	4.83
8	4.50	3.75	3.67	4.75	7.00	8.00	4.67	1.58	.08	4.00	5.67	4.83
9	4.58	3.67	.67	4.83	7.17	8.00	4.58	1.50	.00	4.25	6.17	5.17
10	4.58	3.67	.67	5.08	7.33	8.00	4.42	1.50	.00	4.50	6.50	5.67
11	4.58	3.58	.67	5.08	7.50	7.92	4.25	1.50	.00	4.75	6.67	6.00
12	4.58	3.58	.67	5.08	7.75	7.83	4.00	1.42	3.25	5.00	6.75	6.83
13	4.58	3.58	1.33	4.92	7.75	7.75	3.92	1.42	3.25	5.00	6.83	7.00
14	4.50	3.58	1.50	4.92	8.00	7.58	3.75	1.33	3.17	5.00	6.83	7.00
15	4.50	3.58	1.67	4.75	8.25	7.42	3.58	1.25	3.17	5.00	6.83	6.92
16	4.50	3.58	1.67	4.67	8.75	7.25	3.42	1.17	3.17	5.08	6.75	6.83
17	4.42	3.58	1.67	4.50	9.00	7.00	3.25	1.08	3.17	5.08	6.67	6.67
18	4.42	3.58	1.67	4.42	9.25	6.92	3.08	1.00	3.17	5.08	6.50	6.50
19	4.33	3.58	1.67	4.33	10.00	6.75	3.00	.92	3.17	5.08	6.33	6.33
20	4.25	3.58	1.67	4.25	10.25	6.58	2.92	.83	3.17	5.17	6.08	6.17
21	4.25	3.58	1.67	4.25	10.25	6.42	2.83	.83	3.08	5.17	5.83	6.17
22	4.17	3.58	1.75	4.33	10.17	6.33	2.67	.75	3.08	5.17	5.58	6.17
23	4.17	3.58	1.75	4.42	9.75	6.17	2.50	.75	3.08	5.17	5.42	6.08
24	4.17	3.58	1.83	4.67	9.50	6.00	2.42	.67	3.08	5.17	5.25	6.00
25	4.08	3.58	1.83	5.00	9.50	6.00	2.33	.58	3.08	5.17	5.17	6.00
26	4.08	3.58	2.00	5.42	9.17	5.83	2.17	.50	3.08	5.17	5.00	5.92
27	4.00	3.58	2.17	5.58	9.00	5.83	2.00	.42	3.08	5.17	5.00	5.92
28	4.00	3.58	2.42	5.75	8.75	5.67	2.00	.42	3.08	5.17	5.00	5.92
29	3.92	.....	2.67	5.92	8.50	5.50	2.00	.42	3.08	5.17	5.00	5.83
30	3.92	.....	2.92	6.00	8.50	5.33	2.00	.33	3.08	5.08	5.00	5.83
31	3.92	.....	3.25	.....	8.50	.....	1.92	.33	.....	5.08	.....	5.83

March 9, 10, 11 and 12, waste gates opened; flashboards taken out. March 13, waste gates closed. April 6, waste gates opened. September 12, waste gates closed and flashboards put in.

Spokane River at Dam of the Washington Water Power Company, Spokane, Washington, for 1894.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.75	5.67	3.75	6.50	10.08	12.33	6.75	3.42	1.50	1.25	2.42	3.50
2	5.75	5.50	3.75	6.83	10.00	12.33	6.67	3.33	1.42	1.25	2.50	3.58
3	5.67	5.33	3.92	7.00	9.83	12.33	6.50	3.25	1.42	1.25	2.58	3.58
4	5.58	5.17	3.92	7.00	9.75	12.25	6.33	3.25	1.42	1.25	2.67	3.58
5	5.50	5.00	3.92	7.08	9.58	12.25	6.17	3.17	1.42	1.25	2.67	3.58
6	5.42	5.00	3.92	7.08	9.50	12.25	6.00	3.08	1.42	1.25	2.75	3.58
7	5.33	4.92	3.92	7.08	9.50	12.08	5.92	3.08	1.33	1.25	2.75	3.50
8	5.25	4.92	4.00	7.08	9.42	11.92	5.75	3.00	1.33	1.25	2.83	3.50
9	5.17	4.83	4.00	7.08	9.42	11.67	5.58	2.92	1.33	1.25	2.92	3.50
10	5.00	4.83	4.00	7.25	9.42	11.33	5.42	2.83	1.33	1.83	3.00	3.50
11	4.83	4.75	4.00	7.25	9.33	10.00	5.33	2.75	1.33	1.83	3.17	3.50
12	4.67	4.67	4.00	7.50	9.25	9.83	5.25	2.67	1.33	1.83	3.25	3.50
13	4.67	4.50	4.00	7.83	9.25	9.67	5.17	2.58	1.25	1.83	3.25	3.33
14	4.75	4.50	4.08	8.17	9.17	9.42	5.08	2.50	1.25	1.75	3.25	3.33
15	5.17	4.50	4.08	8.50	9.08	9.17	4.92	2.42	1.25	1.75	3.25	3.25
16	6.25	4.33	4.08	8.83	9.08	9.00	4.83	2.33	1.25	1.75	3.25	3.17
17	7.00	4.33	4.08	8.92	9.33	8.83	4.67	2.25	1.25	1.75	3.25	3.08
18	7.50	4.17	4.17	8.92	9.58	8.75	4.50	2.17	1.25	1.75	3.25	3.08
19	7.58	4.00	4.17	8.83	9.92	8.67	4.33	2.08	1.25	1.67	3.17	3.00
20	7.58	3.92	4.33	8.75	10.08	8.50	4.25	2.00	1.25	1.67	3.08	3.00
21	7.50	3.83	4.42	8.67	10.17	8.33	4.08	1.92	1.25	1.67	3.00	2.92
22	7.33	3.83	4.58	8.67	10.33	8.25	3.92	1.83	1.25	1.67	3.00	2.92
23	7.00	3.83	4.67	8.67	10.50	8.08	3.83	1.75	1.25	1.67	3.00	2.83
24	6.83	3.75	4.67	8.83	10.75	7.92	3.75	1.75	1.25	1.67	3.00	2.83
25	6.67	3.75	4.67	9.08	11.00	7.75	3.75	1.67	1.25	1.67	3.08	2.75
26	6.42	3.75	4.75	9.42	11.33	7.58	3.67	1.58	1.25	1.83	3.08	2.75
27	6.25	3.75	4.92	9.58	11.67	7.42	3.67	1.58	1.25	2.00	3.08	2.75
28	6.08	3.75	5.08	9.92	12.00	7.25	3.58	1.58	1.25	2.17	3.17	2.67
29	6.00	.....	5.33	10.08	12.17	7.08	3.58	1.58	1.25	2.25	3.25	2.58
30	5.92	.....	5.67	10.08	12.17	6.92	3.50	1.50	1.25	2.33	3.42	2.50
31	5.83	.....	6.00	.....	12.42	.....	3.50	1.50	.....	2.33	.....	2.50

April 4, waste gates opened. Flashboards were carried out in high water of April and May. October 10, waste gates closed.

Spokane River at dam of the Washington Water Power Company, Spokane, Washington, for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.42	3.50	4.83	4.17	7.00	6.00	3.33	1.75	2.75	3.00	3.00	3.50
2	2.42	3.42	4.83	4.33	7.17	6.00	3.25	1.75	2.75	3.00	3.00	3.50
3	2.33	3.42	4.92	4.42	7.17	5.83	3.00	1.75	2.75	3.00	3.00	3.50
4	2.33	3.25	5.00	4.50	7.25	5.75	3.00	1.75	2.75	3.00	3.00	3.50
5	2.25	3.17	5.08	4.67	7.25	5.67	3.00	1.67	2.83	3.00	3.00	3.50
6	2.25	3.17	5.08	4.67	7.33	5.58	3.00	1.67	2.83	3.00	3.08	3.50
7	2.25	3.08	5.00	4.75	7.50	5.58	2.83	1.58	2.83	3.00	3.08	3.50
8	2.25	3.00	4.83	4.75	7.50	5.50	2.83	1.58	2.92	3.00	3.17	3.50
9	2.25	2.92	4.83	4.75	7.58	5.33	2.75	1.58	3.00	3.00	3.17	3.50
10	2.33	2.83	4.75	4.83	7.67	5.00	2.67	1.58	3.00	3.00	3.17	3.50
11	2.33	2.83	4.67	4.92	7.67	5.00	2.67	1.58	3.00	3.00	3.17	3.50
12	2.42	2.75	4.50	5.00	7.50	5.00	2.58	1.50	3.08	3.00	3.17	3.58
13	2.67	2.75	4.50	5.00	7.33	5.00	2.58	1.50	3.17	3.00	3.17	3.58
14	3.08	2.67	4.42	5.17	7.00	5.00	2.50	1.42	3.00	3.00	3.17	3.67
15	3.50	2.58	4.42	5.25	7.00	4.67	2.50	1.42	3.00	3.00	3.17	3.67
16	4.00	2.58	4.42	5.33	6.83	4.50	2.42	1.42	3.00	3.00	3.17	3.67
17	4.33	2.58	4.25	5.50	6.75	4.33	2.42	1.42	3.00	3.00	3.17	3.67
18	4.33	2.58	4.17	5.67	6.75	4.25	2.42	1.33	3.00	3.00	3.17	3.67
19	4.33	2.50	4.17	5.67	6.67	4.17	2.33	1.25	3.00	3.00	3.17	3.67
20	4.33	2.50	4.00	5.75	6.58	4.08	2.33	1.17	3.00	3.00	3.17	3.67
21	4.42	2.50	4.00	5.75	6.58	4.00	2.25	1.08	3.00	3.00	3.17	3.67
22	4.25	2.50	3.92	5.75	6.58	3.83	2.25	1.00	3.00	3.00	3.17	3.67
23	4.25	2.67	3.83	5.83	6.58	3.83	2.17	.00	3.00	3.00	3.17	3.67
24	4.17	3.17	3.75	5.83	6.50	3.67	2.08	.00	3.00	3.00	3.17	3.67
25	4.17	3.58	3.75	6.00	6.33	3.58	2.00	.00	3.00	2.83	3.17	3.67
26	4.08	4.00	3.75	6.17	6.33	3.50	2.00	.00	3.00	2.83	3.17	3.67
27	4.00	4.33	3.75	6.50	6.17	3.50	2.00	.00	3.00	2.67	3.25	3.67
28	3.83	4.67	3.67	6.67	6.00	3.50	2.00	2.75	3.00	2.67	3.33	3.67
29	3.67	.....	3.67	6.92	6.00	3.50	1.92	2.75	3.00	2.83	3.33	3.75
30	3.67	.....	3.67	7.00	6.00	3.50	1.83	2.75	3.00	3.00	3.33	3.75
31	3.58	.....	4.00	.....	6.00	.....	1.75	2.75	.....	3.00	.....	3.75

August 23, waste gates opened. August 25, flashboards put in. August 28, one waste gate closed. September 5, other waste gate closed.

Spokane River at Spokane, Washington, for 1896.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.75	5.00	6.33	7.67	7.33	8.42	8.00	3.25	1.83	1.42	1.40	4.70
2	3.75	5.00	6.17	7.50	7.42	8.67	7.83	3.25	1.83	1.42	1.50	4.60
3	3.75	5.00	6.17	7.50	7.42	8.67	7.67	3.17	1.83	1.33	1.50	4.60
4	3.75	5.00	6.00	7.50	7.50	8.75	7.50	3.08	1.75	1.33	1.50	4.70
5	3.83	5.00	6.00	7.33	7.50	8.75	7.33	3.00	1.75	1.33	1.55	5.20
6	3.83	5.00	6.00	7.17	7.58	8.83	7.08	3.00	1.75	1.33	1.55	5.50
7	3.83	5.00	6.00	6.83	7.58	8.92	6.33	2.92	1.67	1.33	1.60	5.60
8	3.83	5.00	6.00	6.83	7.67	8.83	6.58	2.83	1.67	1.33	1.60	5.85
9	3.92	5.00	6.00	6.67	7.67	8.75	6.33	2.83	1.67	1.25	1.65	6.10
10	3.92	5.00	6.00	6.67	7.75	8.75	6.17	2.75	1.67	1.25	1.65	6.30
11	3.92	5.00	6.00	6.67	7.75	8.75	6.00	2.75	1.67	1.25	1.70	6.50
12	3.92	5.00	6.00	6.67	7.75	8.75	5.83	2.67	1.58	1.25	1.80	6.60
13	4.00	5.00	6.00	6.75	7.75	8.67	5.67	2.67	1.58	1.25	1.80	6.90
14	4.00	5.00	6.00	6.92	7.75	8.67	5.50	2.58	1.58	1.25	1.80	7.20
15	4.00	5.00	6.00	6.92	7.75	8.58	5.25	2.58	1.58	1.25	2.10	7.50
16	4.00	5.00	6.00	7.33	7.75	8.58	5.00	2.50	1.58	1.25	3.10	7.60
17	4.00	5.17	5.83	7.50	7.75	8.58	4.75	2.42	1.58	1.25	4.35	7.60
18	4.00	5.17	5.83	7.58	7.67	8.58	4.58	2.42	1.58	1.25	5.30	7.50
19	4.17	5.17	5.67	7.58	7.67	8.58	4.42	2.33	1.58	1.25	6.00	7.40
20	4.17	5.33	5.67	7.58	7.58	8.58	4.25	2.33	1.58	1.25	6.30	7.20
21	4.33	5.33	5.67	7.50	7.50	8.50	4.17	2.25	1.58	1.25	6.30	7.10
22	4.42	5.33	5.83	7.33	7.50	8.50	4.00	2.17	1.58	1.17	6.35	7.00
23	4.50	5.33	6.00	7.17	7.50	8.50	4.00	2.17	1.50	1.17	6.35	6.70
24	4.50	5.33	6.33	7.08	7.50	8.50	3.83	2.08	1.50	1.17	6.20	6.60
25	4.67	5.42	7.00	7.00	7.58	8.50	3.67	2.08	1.50	a1.4	6.20	6.60
26	4.67	5.42	7.00	7.00	7.58	8.42	3.50	2.08	1.50	1.45	6.00	6.20
27	5.00	5.42	7.33	7.08	7.67	8.33	3.42	2.08	1.50	1.45	5.60	6.10
28	5.00	5.83	7.50	7.17	7.75	8.33	3.42	2.08	1.50	1.40	5.50	6.00
29	5.00	6.33	7.50	7.17	7.83	8.25	3.42	2.00	1.42	1.40	5.20	5.80
30	5.00	.....	7.67	7.25	8.00	8.17	3.33	1.92	1.42	1.40	5.00	5.60
31	5.00	.....	7.67	.....	8.17	.....	3.33	1.92	.....	1.40	.....	5.50

a New gage rod.

Umatilla River at Gibbon, Oregon.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	0.80	0.80	0.80	1.00	1.60	17	.....	0.80	0.80	0.80	4.00	2.40
2	.....	.75	.80	.80	1.00	1.60	18	.....	.80	.80	.85	3.80	2.30
3	.....	.75	.80	.80	1.00	1.60	19	.....	.80	.80	.85	3.45	2.25
4	.....	.90	.80	.80	1.10	2.05	20	.....	.80	.80	.85	3.00	2.20
5	.....	.95	.80	.80	1.10	2.45	21	.....	.80	.80	.85	2.70	2.10
6	.....	.85	.80	.80	1.00	2.40	22	0.85	.80	.80	.85	2.45	.....
7	.....	.85	.80	.80	1.00	2.30	23	.90	.80	.80	.80	2.30	2.05
8	.....	.85	.80	.80	2.30	2.20	24	.85	.80	.80	.80	2.10	2.00
9	.....	.85	.80	.80	1.90	2.20	25	.85	.80	.80	.80	2.05	1.90
10	.....	.85	.80	.90	2.20	2.30	26	.85	.80	.80	.80	1.95	.....
11	.....	.85	.90	.90	1.90	2.35	27	.85	.80	.80	.85	1.80	1.90
12	.....	.85	.90	.85	1.70	3.90	28	.85	.80	.80	.85	1.75	1.85
13	.....	.85	.85	.85	1.70	3.80	29	.85	.80	.80	.85	1.65	.....
14	.....	.85	.85	.85	3.20	3.20	30	.80	.80	.80	.90	1.60	1.80
15	.....	.85	.85	.85	4.10	2.80	31	.80	.90	.....	1.15	.....	.....
16	.....	.80	.85	.80	4.00	2.55							

Sacramento River at Redbluff, California.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.00	10.70	3.40	7.40	9.70	6.10	2.40	0.70	0.40	0.40	0.80	3.60
2	1.00	8.90	3.40	6.90	9.20	5.90	2.30	.70	.40	.40	.70	4.50
3	1.00	7.90	3.30	6.30	9.10	5.90	2.30	.70	.40	.40	.60	4.80
4	1.00	6.90	3.00	6.00	16.90	5.80	2.20	.60	.30	.40	.50	4.00
5	1.00	6.20	3.10	5.80	15.30	5.80	2.10	.60	.30	.40	.50	3.90
6	1.00	5.90	3.80	7.20	12.60	5.80	1.90	.60	.30	.30	.50	4.20
7	1.00	5.20	5.50	9.00	10.90	5.50	1.90	.50	.30	.30	.30	4.20
8	1.00	4.90	5.80	8.50	9.80	5.40	1.80	.50	.30	.30	.40	4.00
9	1.00	4.70	6.20	7.10	9.10	5.20	1.70	.50	.30	.30	.80	4.00
10	1.00	4.60	5.40	7.30	8.40	4.80	1.70	.50	.30	.30	.80	4.00
11	1.00	4.20	4.90	6.90	11.50	4.40	1.70	.50	.30	.30	.80	4.60
12	1.00	4.10	4.40	6.40	9.80	4.20	1.70	.50	.30	.30	.60	4.80
13	1.00	4.00	4.40	6.10	8.80	4.20	1.60	.40	.30	.30	.60	6.20
14	3.20	3.80	4.40	7.20	8.10	4.20	1.60	.40	.30	.30	.60	10.60
15	7.20	3.80	4.20	6.50	7.60	4.20	1.60	.40	.30	.30	.60	20.60
16	11.60	3.70	4.00	6.10	7.20	4.00	1.50	.40	.30	.30	1.20	14.40
17	23.50	3.40	4.00	5.70	6.80	3.90	1.50	.40	.30	.30	6.60	9.70
18	23.00	3.20	3.90	5.40	6.50	3.80	1.40	.40	.30	.30	5.20	9.20
19	22.30	3.10	3.90	5.50	6.20	3.60	1.30	.40	.30	.30	3.00	8.30
20	20.90	3.00	4.00	5.20	5.90	3.40	1.30	.40	.60	.30	3.40	7.30
21	22.40	2.90	6.60	5.10	5.80	3.30	1.30	.40	.60	.30	2.80	7.10
22	19.00	2.90	7.30	5.20	8.30	3.20	1.20	.40	.60	.30	2.90	7.10
23	14.80	2.90	9.90	5.50	8.10	3.10	1.20	.40	.50	.30	6.70	7.60
24	13.20	2.70	11.90	13.70	7.40	2.90	1.10	.40	.50	.30	12.50	9.40
25	19.60	2.70	13.10	15.30	6.60	2.90	1.10	.40	.50	.30	7.60	8.20
26	16.00	2.70	13.60	13.50	6.90	2.80	1.10	.40	.40	.30	3.90	10.40
27	24.10	2.70	15.50	12.70	6.80	2.70	1.00	.40	.40	1.30	3.20	11.60
28	19.90	2.80	13.00	11.40	6.90	2.60	1.00	.40	.40	.90	2.70	16.40
29	16.10	2.80	10.40	9.50	6.90	2.50	.90	.30	.40	.70	3.30	15.20
30	12.00	.....	8.50	9.20	6.80	2.50	.90	.30	.40	.70	3.30	10.80
31	9.40	.....	8.20	.....	6.50	.....	.80	.30	.....	.60	.....	9.40

Sacramento River at Jellys Ferry, California.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.70	13.60	7.90	11.30	12.90	10.30	6.90	5.90	5.70	5.60	5.90	6.80
2	5.70	12.90	7.80	10.80	13.30	10.30	6.80	5.90	5.70	5.60	5.80	6.90
3	5.70	11.90	7.90	10.40	13.40	10.10	6.70	5.90	5.60	5.60	5.80	7.00
4	5.70	11.20	7.70	10.10	21.20	10.10	6.70	5.80	5.60	5.60	5.70	7.00
5	5.70	10.60	7.70	10.20	19.00	10.10	6.60	5.80	5.60	5.60	5.70	7.00
6	5.70	10.10	8.10	12.50	16.50	10.00	6.60	5.80	5.60	5.60	5.70	7.10
7	5.70	9.80	9.60	11.50	15.10	9.80	6.60	5.80	5.60	5.50	5.70	7.10
8	5.70	9.40	10.30	11.50	14.00	9.70	6.50	5.80	5.60	5.50	5.70	7.00
9	5.70	9.10	10.60	11.30	13.10	9.40	6.50	5.80	5.60	5.50	5.70	6.90
10	5.70	9.00	9.70	10.60	12.40	9.20	6.50	5.80	5.60	5.50	6.10	6.80
11	5.70	8.70	9.30	10.40	14.50	8.90	6.40	5.70	5.60	5.50	5.90	6.70
12	5.70	8.60	9.00	10.20	13.70	8.80	6.40	5.70	5.60	5.50	5.80	7.20
13	5.70	8.30	8.90	11.20	12.90	8.60	6.40	5.70	5.60	5.50	5.80	11.20
14	5.90	8.20	8.80	10.50	12.40	8.60	6.30	5.70	5.60	5.50	5.70	16.30
15	11.20	8.10	8.50	10.10	11.90	8.40	6.30	5.70	5.50	5.50	5.70	24.00
16	19.00	7.90	8.50	9.80	11.30	8.30	6.30	5.70	5.50	5.50	8.00	16.70
17	27.70	7.80	8.40	9.60	10.90	8.20	6.30	5.70	5.50	5.50	11.70	13.20
18	23.70	7.70	8.30	9.60	10.70	8.00	6.20	5.70	5.50	5.50	9.00	11.10
19	22.80	7.60	8.20	9.60	10.50	8.00	6.20	5.70	5.50	5.50	7.50	9.90
20	27.80	7.50	8.80	9.30	10.20	7.80	6.20	5,70	5.70	5.50	8.50	9.30
21	26.50	7.50	10.60	9.40	16.00	7.70	6.10	5.70	5.70	5.50	7.40	8.80
22	21.80	7.50	11.80	9.40	12.60	7.60	6.10	5.70	5.70	5.50	10.50	8.40
23	19.50	7.40	14.10	10.00	12.30	7.50	6.10	5.70	5.70	5.50	10.60	8.00
24	18.30	7.40	16.30	18.50	11.60	7.40	6.00	5.60	5.70	5.50	15.40	7.90
25	21.90	7.30	17.00	16.90	11.00	7.30	6.00	5.60	5.70	5.50	11.40	7.70
26	20.50	7.30	17.80	15.80	10.90	7.20	6.00	5.60	5.70	5.60	9.30	7.60
27	29.70	7.50	19.10	14.20	10.90	7.10	6.00	5.60	5.60	6.50	8.30	10.00
28	24.30	8.10	16.40	13.10	10.80	7.10	6.00	5.60	5.60	5.90	7.70	15.20
29	19.80	7.90	14.60	12.90	11.00	7.00	6.00	5.60	5.60	5.70	7.20	15.60
30	17.00	.....	13.30	13.50	11.00	7.00	6.00	5.60	5.60	5.70	7.10	16.20
31	14.60	.....	12.20	.....	10.60	.....	5.90	5.70	.....	5.70	.....	16.40

Stanislaus River at Oakdale, California.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.00	3.90	3.70	5.40	5.60	9.90	5.00	2.80	3.60	2.30	2.40	3.00
2	2.10	3.80	3.40	5.30	5.60	10.50	4.80	2.70	3.20	2.30	2.40	3.00
3	2.10	3.70	3.50	5.20	5.60	9.10	4.70	2.70	2.80	2.30	2.40	3.00
4	2.10	3.60	3.40	5.00	5.70	8.20	4.60	2.40	2.60	2.50	2.40	3.00
5	2.10	3.60	3.30	4.80	6.30	8.30	4.70	2.70	2.50	2.20	2.40	2.90
6	2.10	3.40	3.30	5.60	5.80	8.60	5.70	2.60	2.50	2.20	2.30	2.90
7	2.10	3.30	3.30	5.60	5.40	8.70	5.00	2.50	2.50	2.20	2.30	2.90
8	2.10	3.30	3.30	5.00	5.30	9.10	4.70	2.50	2.70	2.20	2.40	2.80
9	2.10	3.20	3.30	4.90	5.20	9.90	4.90	2.50	2.50	2.20	3.80	2.80
10	2.10	3.20	3.30	5.10	5.00	9.50	4.60	2.50	2.50	2.30	3.30	2.80
11	2.10	3.20	3.20	4.90	5.20	8.60	4.60	2.50	2.50	2.30	2.80	2.80
12	2.00	3.20	3.50	5.00	5.70	9.10	4.30	2.50	2.40	2.20	2.60	2.80
13	2.20	3.10	3.60	5.10	5.40	8.60	4.10	2.50	2.40	2.20	2.50	4.50
14	2.20	3.10	3.70	7.60	5.90	9.00	3.80	2.50	2.30	2.20	2.50	4.00
15	2.20	3.10	3.90	6.30	6.10	8.80	3.70	2.50	2.30	2.20	2.50	3.50
16	2.30	3.10	4.00	5.70	5.90	8.20	3.60	2.40	2.30	2.20	2.50	3.50
17	3.70	3.10	4.80	5.40	6.00	8.40	3.50	2.40	2.30	2.20	2.50	3.30
18	5.90	3.10	4.70	5.10	6.00	7.90	3.70	2.40	2.30	2.20	2.60	3.10
19	6.60	3.20	4.50	4.90	5.70	7.00	3.60	2.40	2.30	2.20	2.70	3.00
20	8.30	3.20	4.90	4.70	5.60	6.90	3.50	2.40	2.30	2.20	2.70	3.00
21	8.30	3.20	6.10	4.70	5.90	7.60	3.40	2.50	2.40	2.20	2.90	2.90
22	7.20	3.20	6.60	4.90	6.20	7.50	3.30	2.50	2.40	2.20	3.10	2.90
23	5.50	3.20	6.40	5.10	6.80	6.80	3.30	2.40	2.40	2.20	3.00	2.90
24	4.90	3.20	6.10	9.30	7.10	7.10	3.20	2.60	2.40	2.20	6.70	2.80
25	4.50	3.20	6.30	9.50	7.90	6.50	3.10	2.50	2.40	2.20	5.50	2.80
26	4.40	3.30	7.80	7.60	9.00	6.00	3.10	2.40	2.40	2.20	4.00	2.90
27	7.70	3.40	11.00	6.40	9.60	6.00	3.10	2.30	2.40	2.50	3.60	3.30
28	7.20	3.50	7.30	5.90	10.40	6.00	3.00	2.20	2.40	2.60	3.40	3.40
29	5.00	3.80	6.40	5.70	11.50	5.90	3.00	2.20	2.30	2.40	3.10	3.30
30	4.50	.....	6.10	5.60	9.90	5.30	2.90	2.30	2.30	2.30	3.00	3.20
31	3.90	.....	5.70	.....	10.30	.....	2.80	5.10	.....	2.30	.....	4.30

Tuolumne River at Lagrange, California.

Day.	Jan.	Feb.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.50	5.80	.....	6.40	9.30	7.40	5.00	5.70	4.20	4.50	5.10
2	4.50	5.80	.....	6.50	9.30	7.20	5.00	5.20	4.20	4.50	5.20
3	4.50	5.60	.....	6.70	9.60	7.10	5.00	5.00	4.10	4.40	5.20
4	4.50	5.50	.....	6.90	9.20	7.20	4.90	4.90	4.10	4.30	5.20
5	4.50	5.50	.....	7.00	9.30	7.70	4.80	4.80	4.10	4.30	5.20
6	4.50	5.40	.....	6.80	9.20	7.70	4.80	4.70	4.10	4.30	5.10
7	4.50	5.40	.....	6.70	9.60	7.50	4.70	5.20	4.00	4.30	5.10
8	4.50	5.30	.....	6.70	9.20	7.30	4.70	5.10	4.00	4.30	5.00
9	4.50	5.30	.....	6.70	9.60	7.40	4.60	4.80	4.00	4.30	5.00
10	4.50	5.30	.....	6.60	9.20	7.40	4.50	4.70	4.00	6.40	5.00
11	4.50	5.30	.....	6.70	9.20	7.40	4.50	4.60	4.00	5.60	5.00
12	4.50	5.30	.....	6.80	9.20	7.10	4.50	4.50	4.00	5.20	5.00
13	4.50	5.30	.....	6.60	9.40	6.80	4.50	4.50	4.00	5.00	6.80
14	4.50	5.30	.....	6.50	9.20	6.50	4.50	4.40	3.90	4.90	6.10
15	4.50	5.30	7.00	6.60	9.50	6.30	4.50	4.30	3.90	4.80	5.70
16	4.90	5.30	6.90	6.40	9.50	6.30	4.50	4.20	3.90	4.70	5.60
17	5.60	5.30	6.60	6.40	9.20	6.40	4.40	4.20	3.90	4.80	5.40
18	8.50	5.30	6.50	6.60	9.20	6.20	4.40	4.20	3.90	5.10	5.20
19	7.20	5.30	6.40	6.30	9.10	6.10	4.40	4.10	3.90	5.20	5.10
20	8.30	5.30	6.30	6.50	9.80	5.90	4.50	4.10	3.90	5.20	5.10
21	8.10	5.30	6.50	6.80	8.50	5.90	4.50	4.30	3.90	5.50	5.10
22	7.30	5.30	6.40	7.00	8.60	5.80	4.50	4.30	3.90	5.30	5.00
23	7.00	5.30	6.30	6.90	8.60	5.70	4.50	4.50	3.90	5.30	5.00
24	6.70	5.30	8.40	7.10	8.10	5.60	4.40	4.50	3.90	7.90	5.00
25	6.10	5.30	9.10	7.80	8.20	5.40	4.40	4.40	3.90	7.00	4.90
26	5.60	5.30	8.50	8.50	8.00	5.70	4.40	4.30	3.90	6.20	4.90
27	8.90	5.30	8.10	8.90	7.90	5.60	4.30	4.30	4.20	5.70	5.10
28	7.60	5.30	7.90	9.20	7.90	5.40	4.30	4.30	4.50	5.50	5.40
29	7.50	5.30	7.20	10.20	8.10	5.30	4.30	4.30	4.40	5.30	5.50
30	7.10	.....	6.70	9.60	7.60	5.20	4.30	4.20	4.40	5.10	5.30
31	6.40	.....	.....	9.60	.....	5.10	6.50	.....	4.40	.....	5.70

Tuolumne River at Modesto, California.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.80	6.30	6.00	7.50	7.80	16.40	10.30	5.30	7.40	3.70	3.80	5.20
2	3.80	6.10	5.60	7.10	7.80	16.90	9.90	5.00	6.00	3.60	3.80	5.10
3	3.70	5.90	5.60	7.20	7.70	17.00	9.50	4.80	5.30	3.60	3.80	5.00
4	3.60	5.80	5.30	7.10	7.90	14.80	9.60	4.80	4.90	3.50	3.80	5.10
5	3.60	5.70	5.20	6.90	8.10	13.80	9.50	4.90	4.80	3.50	3.70	5.00
6	3.60	5.50	5.10	6.70	8.70	14.30	12.50	4.90	4.40	3.50	3.70	4.90
7	3.70	5.30	5.20	7.20	7.80	15.30	10.70	4.70	4.30	3.50	3.70	4.80
8	3.70	5.30	5.30	6.80	7.50	17.10	10.00	4.70	4.80	3.30	3.70	4.70
9	3.70	5.30	5.30	6.70	7.40	17.60	10.10	4.60	4.70	3.30	3.80	4.60
10	3.70	5.10	5.40	7.20	7.10	17.60	10.30	4.50	4.60	3.30	3.80	4.70
11	3.70	5.30	5.60	7.20	7.00	16.30	9.90	4.60	4.40	3.30	7.20	4.70
12	3.80	5.10	5.80	6.70	7.70	16.80	10.50	4.50	4.30	3.30	5.70	4.60
13	3.90	5.10	6.00	6.80	7.40	16.80	9.70	4.50	4.10	3.20	5.20	4.60
14	3.90	5.20	6.30	7.70	7.70	16.80	9.30	4.40	3.90	3.20	4.70	8.00
15	4.30	5.00	6.60	10.20	8.20	16.70	8.80	4.30	3.90	3.10	4.50	6.40
16	4.10	5.00	6.60	8.00	8.50	16.70	8.30	4.20	3.90	3.10	4.40	6.30
17	4.40	5.00	6.60	7.40	8.10	16.60	8.20	4.20	3.70	3.00	4.40	5.50
18	10.80	5.20	6.40	6.80	8.40	16.70	8.00	4.10	3.70	3.00	4.40	5.30
19	15.30	5.30	6.40	6.70	8.30	15.00	7.90	4.10	3.70	3.00	4.70	5.20
20	9.20	5.30	6.60	6.70	7.70	13.90	7.40	4.10	3.60	3.00	4.90	4.80
21	15.20	5.40	7.80	6.40	7.70	13.70	7.20	4.10	3.50	3.20	4.90	4.60
22	12.80	5.40	7.50	6.50	8.50	13.80	7.00	4.00	3.70	3.20	5.40	4.60
23	10.30	5.10	8.00	7.00	8.50	13.30	6.80	4.00	3.80	3.20	5.30	4.40
24	8.10	5.10	8.20	6.80	9.00	13.50	6.70	4.00	3.80	3.20	7.00	4.30
25	6.90	5.00	8.00	17.70	10.40	13.50	6.40	4.00	4.00	3.20	11.70	4.30
26	7.00	5.40	8.40	11.70	11.90	12.30	6.30	4.00	3.90	3.20	8.70	4.30
27	9.30	5.50	15.10	10.70	13.40	11.70	6.70	4.00	3.80	3.40	6.50	4.70
28	16.70	5.50	11.90	9.70	14.70	11.50	6.50	3.90	3.80	4.20	5.70	4.90
29	9.90	5.80	9.50	8.30	16.70	11.70	6.10	3.80	3.80	4.00	5.50	5.80
30	8.30	.....	8.40	8.40	17.60	11.00	5.80	3.80	3.70	3.80	5.30	5.50
31	6.80	.....	8.00	.....	16.10	.....	5.60	4.70	.....	3.80	.....	6.00

San Joaquin River at Herndon, California.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.60	3.70	3.80	4.60	4.50	9.20	5.90	3.50	3.40	2.30	2.80	2.80
2	2.50	3.70	3.90	4.40	4.60	9.60	5.70	3.40	3.30	2.30	2.70	2.70
3	2.50	3.60	3.80	4.20	4.70	9.70	5.50	3.50	3.20	2.30	2.70	2.70
4	2.50	3.60	3.70	4.10	4.90	9.10	5.40	3.50	3.10	2.50	2.70	2.70
5	2.60	3.40	3.50	4.10	4.90	9.10	6.00	3.40	3.00	2.50	2.70	2.70
6	2.70	3.30	3.40	4.00	5.30	8.90	6.60	3.40	3.00	2.40	2.70	2.80
7	2.70	3.30	3.40	4.20	4.80	8.80	6.10	3.30	2.80	2.40	2.70	3.00
8	2.60	3.20	3.40	4.00	4.50	8.80	5.80	3.30	3.20	2.30	2.70	2.90
9	2.60	3.20	3.50	4.00	4.50	8.70	5.70	3.30	3.30	2.30	2.70	2.80
10	2.60	3.30	3.50	4.00	4.30	8.90	5.80	3.30	3.10	2.30	2.70	2.80
11	2.60	3.30	3.60	4.30	4.30	8.70	6.90	3.30	3.10	2.30	3.30	2.80
12	2.60	3.30	3.70	4.20	4.60	8.00	6.10	3.30	2.90	2.30	3.20	2.80
13	2.60	3.30	3.80	4.10	4.60	7.80	5.90	3.30	2.90	2.30	3.00	2.80
14	2.60	3.30	3.80	4.20	4.90	8.80	5.60	3.30	2.80	2.30	2.90	3.30
15	2.60	3.30	3.80	4.10	5.20	8.80	5.20	3.30	2.70	2.30	2.90	3.80
16	2.80	3.30	4.00	4.30	5.20	8.70	4.80	3.30	2.70	2.30	2.80	3.50
17	3.20	3.30	4.00	5.60	5.00	8.90	4.70	3.30	2.70	2.30	2.80	3.30
18	4.20	3.30	4.00	4.70	5.20	8.70	5.20	3.30	2.70	2.30	2.80	3.10
19	8.50	3.30	4.00	4.20	5.00	8.00	4.80	3.50	2.70	2.30	2.80	3.00
20	5.00	3.30	4.00	4.00	4.80	7.80	4.70	3.50	2.60	2.30	2.80	3.00
21	8.00	3.30	4.30	4.00	5.00	8.00	4.50	3.40	2.50	2.30	2.80	2.90
22	6.50	3.30	4.30	4.00	5.00	7.70	4.40	3.30	2.50	2.40	2.70	2.80
23	4.80	3.30	4.70	3.90	5.10	7.30	4.60	3.30	2.50	2.40	2.80	2.80
24	4.30	3.40	4.80	3.90	5.60	7.00	4.50	3.30	2.50	2.30	3.00	2.70
25	4.00	3.40	4.70	4.00	6.10	7.00	4.50	3.30	2.50	2.30	4.20	2.70
26	3.80	3.50	4.80	5.90	7.10	6.60	4.50	3.10	2.60	2.30	3.70	2.80
27	4.00	3.50	8.30	5.40	7.10	6.40	4.40	3.00	2.50	2.50	3.70	2.80
28	5.00	3.50	5.90	4.80	8.10	6.30	4.00	3.00	2.50	2.50	3.20	3.00
29	4.30	3.80	5.40	4.60	10.20	6.30	3.90	3.00	2.30	3.00	3.00	3.10
30	4.00	.....	5.00	4.70	9.30	6.30	3.70	3.00	3.30	3.00	2.90	3.10
31	3.80	.....	4.70	.....	8.50	.....	3.70	3.00	.....	2.80	.....	3.00

Kings River at Red Mountain, California.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	*4.00*	5.30	5.30	*5.00*	*6.00*	*10.40*	*7.90*	*5.60*	*4.50*	*3.90*	4.20	*4.30*
2	*4.00*	5.10	5.10	*5.20*	*6.00*	*10.40*	7.60	*5.50*	*4.40*	3.90	*4.20*	4.30
3	*4.00*	5.10	5.30	*5.30*	*6.00*	*10.40*	*8.00*	5.50	*4.40*	*3.90*	*4.20*	*4.30*
4	*4.00*	5.10	5.30	*5.40*	*7.00*	*10.40*	*8.40*	*5.30*	4.40	*3.90*	*4.10*	*4.30*
5	*4.00*	5.00	5.30	*5.50*	*7.00*	*10.40*	8.70	*5.20*	*4.40*	*3.90*	4.10	*4.30*
6	*4.00*	4.90	5.30	*6.00*	*8.00*	*10.40*	*8.70*	*5.10*	*4.50*	*3.80*	*4.10*	4.30
7	*4.00*	4.90	5.20	*6.50*	*8.00*	10.40	*8.70*	5.00	4.50	*3.80*	*4.00*	*4.30*
8	*4.00*	4.90	5.30	*7.00*	*7.00*	*10.40*	*8.70*	*5.00*	*4.50*	3.80	4.00	*4.30*
9	*4.00*	4.90	5.40	*7.50*	*6.00*	*10.40*	*8.60*	4.90	*4.50*	*3.80*	*4.30*	*4.30*
10	*4.00*	4.80	5.50	*8.00*	*5.50*	*11.40*	*8.60*	*4.90*	*4.50*	*3.80*	*4.60*	*4.30*
11	*4.00*	4.80	5.70	*7.00*	*5.50*	11.40	8.60	*4.90*	4.50	3.80	4.90	*4.30*
12	4.00	4.80	5.90	6.40	*5.50*	10.90	8.20	*4.80*	*4.40*	*3.80*	4.60	4.30
13	4.00	4.80	6.00	6.90	*5.50*	*10.70*	*7.80*	*4.80*	4.30	*3.80*	*4.50*	4.20
14	4.00	4.80	6.00	7.50	*7.00*	10.50	7.30	4.80	*4.30*	*3.80*	*4.40*	*4.20*
15	4.00	4.80	5.90	7.10	*7.00*	*10.60*	*7.20*	*4.80*	*4.20*	3.80	4.30	*4.30*
16	4.30	4.90	5.80	*6.00*	*8.00*	*10.80*	*7.10*	*4.80*	*4.10*	*3.80*	*4.30*	*4.40*
17	4.90	4.90	5.80	*5.00*	*8.00*	*10.90*	7.00	4.80	4.10	*3.80*	*4.20*	4.40
18	9.20	4.90	6.00	*4.00*	*8.00*	*11.00*	*6.90*	*4.90*	*4.10*	*3.80*	*4.10*	*4.40*
19	7.00	4.90	6.00	*4.50*	*8.00*	*10.70*	*6.70*	*4.90*	*4.00*	*3.80*	4.10	*4.30*
20	6.40	5.00	6.30	*5.00*	*8.00*	*10.40*	6.50	*5.00*	4.00	*3.80*	*4.10*	4.20
21	9.80	5.00	6.40	*5.00*	*8.00*	10.10	6.50	5.00	*4.00*	3.80	*4.10*	*4.20*
22	7.10	4.90	6.40	*5.00*	*8.00*	*9.80*	8.50	*5.00*	*4.10*	*3.80*	4.10	*4.20*
23	6.40	4.90	6.70	*5.50*	*8.00*	*9.50*	*7.50*	4.80	*4.20*	*3.80*	*4.50*	4.20
24	5.90	4.90	6.90	*6.00*	*8.00*	*9.20*	*7.00*	*4.80*	4.20	*3.80*	*5.00*	*4.20*
25	5.70	5.10	8.80	*6.50*	*9.00*	8.90	*6.50*	*4.70*	*4.20*	3.80	5.40	*4.20*
26	5.70	5.10	*8.00*	*8.00*	*10.00*	*8.80*	*6.30*	*4.70*	*4.10*	*3.90*	4.80	*4.30*
27	5.50	5.10	7.20	*8.00*	*11.00*	*8.80*	6.20	*4.70*	4.10	*4.30*	*4.60*	4.20
28	6.00	5.50	*6.50*	*7.50*	*12.00*	8.80	*6.00*	*4.60*	*4.10*	4.30	*4.40*	*4.20*
29	5.70	5.50	*6.00*	*6.00*	*12.00*	*8.50*	*5.80*	4.60	*4.00*	*4.30*	4.20	*4.20*
30	5.40	.....	*5.50*	*6.00*	*11.00*	*8.20*	5.60	*4.60*	*4.00*	*4.30*	*4.20*	*4.30*
31	5.30	.....	*5.00*	.....	*10.00*	.....	*5.60*	4.50	.....	*4.30*	.....	4.30

Figures in italics are estimated from observations taken at Kingsburg, on the same river, and from other rod readings at Red Mountain.

Kings River at Kingsburg, California.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.20	5.20	4.10	4.30	4.00	10.30	6.50	3.50	3.70	4.40	4.40	4.40
2	2.20	5.10	4.30	4.10	4.40	10.30	6.00	3.30	3.70	4.50	4.30	4.50
3	2.20	5.00	5.10	4.00	4.80	9.90	6.10	3.30	3.70	4.50	4.30	4.50
4	2.20	4.80	5.10	3.90	5.40	9.30	6.00	3.30	3.70	4.50	4.20	4.50
5	2.20	4.60	5.10	3.80	5.90	9.30	6.70	3.30	3.70	4.50	4.00	4.50
6	2.20	4.60	4.60	3.30	6.50	9.30	7.10	3.30	3.70	4.60	3.80	4.50
7	2.20	4.50	3.60	3.10	5.90	9.60	6.70	3.20	3.70	4.60	3.80	4.50
8	2.20	4.20	3.10	3.00	5.00	10.30	6.50	3.20	3.70	4.60	3.70	4.40
9	2.20	3.80	2.90	3.00	4.60	10.50	6.30	3.20	3.80	4.50	3.70	4.30
10	2.20	3.70	2.80	6.00	4.20	10.70	6.40	3.20	3.80	4.50	3.60	4.30
11	2.10	3.60	2.90	5.70	3.70	9.90	6.70	3.30	3.70	4.50	4.00	4.40
12	2.10	3.50	3.10	4.60	4.00	10.00	6.50	3.60	3.80	4.50	4.90	4.50
13	2.10	3.30	3.50	4.00	4.70	9.90	6.30	3.80	3.70	4.60	4.50	4.30
14	2.20	3.10	3.60	3.00	5.30	9.60	6.10	3.80	3.60	4.50	4.30	4.80
15	2.20	2.80	3.80	6.10	6.20	9.50	5.90	3.80	3.60	4.50	4.00	3.50
16	2.20	2.80	3.60	4.60	6.30	9.30	5.50	3.70	3.50	4.50	3.90	3.20
17	3.30	2.70	3.20	3.70	5.80	9.80	5.50	3.70	3.50	4.30	3.70	3.30
18	5.40	3.00	3.30	3.10	6.20	9.30	5.60	3.70	3.50	3.80	3.50	3.70
19	8.70	3.00	3.70	3.00	6.20	8.70	5.60	3.80	3.50	3.30	3.50	4.00
20	6.50	3.00	3.70	4.30	5.90	8.40	5.00	3.90	3.50	3.30	3.70	4.00
21	8.00	2.90	4.20	4.20	6.20	8.50	4.70	3.80	3.50	3.30	3.70	4.10
22	7.70	2.90	4.50	4.00	6.40	8.00	4.60	3.80	3.50	3.30	3.60	4.10
23	6.50	2.60	4.50	3.40	6.10	7.70	4.30	3.70	3.40	3.10	3.70	4.00
24	6.20	2.40	5.00	3.30	6.60	7.20	6.40	3.70	3.40	3.10	3.80	4.00
25	5.90	2.50	5.80	5.00	7.40	7.00	5.70	3.70	3.40	3.00	4.70	3.80
26	5.90	2.50	5.50	7.20	8.40	6.80	5.40	3.70	3.40	3.00	5.30	3.80
27	5.80	2.50	8.00	6.60	9.30	6.70	4.90	3.70	4.10	3.50	4.70	3.90
28	6.10	2.60	6.30	5.70	10.30	6.70	4.30	3.70	4.30	4.00	4.60	4.20
29	6.10	3.00	5.80	4.70	11.10	6.70	3.90	3.70	4.30	4.50	4.50	4.40
30	5.80	.....	5.20	4.80	10.20	6.50	3.70	3.70	4.30	4.40	4.40	4.30
31	5.50	.....	4.80	.....	9.80	.....	3.60	3.70	.....	4.40	.....	4.20

Santa Ana River at Warmsprings, California.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	14.50	16.20	16.00	15.50	12.00	12.00
2	14.50	15.30	16.20	16.50	12.00	12.00
3	15.00	16.00	16.00	15.30	12.00	12.30
4	15.00	15.50	14.50	15.00	12.00	12.30
5	15.00	15.70	14.50	13.70	12.00	12.30
6	15.00	15.30	12.50	13.50	12.00	12.30
7	14.00	16.70	15.50	14.50	11.50	12.30
8	14.00	15.30	15.50	14.50	11.50	12.30
9	15.50	15.30	15.30	14.00	11.50	12.30
10	15.70	15.30	15.20	15.00	11.50	12.30
11	15.50	15.50	11.00	15.50	11.50	12.30
12	16.30	15.20	11.30	15.00	11.70	12.30
13	16.50	15.50	13.50	14.00	11.50	12.30
14	14.50	15.20	15.00	14.00	11.50	12.30
15	15.50	15.20	15.00	14.20	11.50	12.30
16	15.00	a 15.20	16.00	13.00	11.50	12.50
17	16.00	13.20	16.50	14.00	11.50	12.50
18	16.00	13.00	16.30	14.30	11.50	12.50
19	16.00	16.00	16.00	14.30	11.50	12.50
20	16.00	14.00	15.50	14.30	11.50	12.50
21	16.00	14.20	14.50	12.70	11.70	12.50
22	16.50	14.30	14.30	13.50	11.80	12.50
23	16.50	12.00	13.50	13.30	12.00	12.20
24	16.50	12.20	13.30	13.00	12.00	12.20
25	15.50	12.70	14.00	13.00	14.30	12.30
26	14.00	13.20	14.70	13.00	12.50	12.00
27	15.00	13.20	13.00	a 21.00	12.50	12.00
28	15.00	14.30	13.50	14.00	12.30	13.00
29	16.50	16.00	14.00	14.00	12.30	13.00
30	15.70	16.00	15.00	14.00	12.30	12.70
31	16.20	14.20	.....	14.00	.....	12.30

a On August 16 the discharge gates of Bear Valley Dam were temporarily closed on account of a storm, and on October 27 they were closed for the season. Discharge of Santa Ana Canal is not included in the above statement.

CURRENT METERS RATED IN 1896.

No. 16. Large Haskell meter. Property of B. M. Hall, Atlanta, Ga. Last rated July 14, 1896, and returned to B. M. Hall July 17, 1896.

No. 25. Small Haskell meter. Returned to office December 12, 1895; rated July 27, 1896, by A. P. Davis at the Kensington station, Md.; sent to Prof. A. L. Lamb, Port Deposit, Md., November 12, 1896.

No. 27. Small Haskell meter. Rated June 27, 1896, by A. P. Davis at Kensington station, Md.; sent to Oskar Huber, Spokane, Wash., October 20, 1896.

No. 63. Large Price electric meter. Rated by J. B. Lippincott and C. C. Babb June 18, 1896, at rating station, Kern County, Cal.; transferred by J. B. Lippincott to C. C. Babb and used by him during summer of 1896; last rated December 10, 1896, by C. C. Babb at Kensington station, Md.

No. 67. Large Price electric meter. Purchased July 2, 1896; rated July 14; sent to W. Richins, Arizona, July 27, 1896; was damaged in shipment and returned to this office for repairs August 26, 1896; repaired and rated September 25, at Kensington, Md. Sent to J. B. Lippincott, Los Angeles, Cal. Sepember 26, 1896.

No. 68. Large Price electric meter. Purchased July 2, 1896; rated July 28, at Kensington station, Md., and used during the season of 1896 by E. G. Paul.

No. 69. Large Price electric meter. Purchased July 20, 1896; rated July 28, 1896, by E. G. Paul at Kensington station, Md., and sent August 26, 1896, to W. Richins for use in Queen Creek, Ariz.

No. 70. Large Price electric meter. Received December 15, 1896, to replace No. 62, large Price electric meter, which was destroyed by fire while in charge of a transportation company. Rated December 15, 1896, by E. G. Paul at Kensington station, Md.

No. 91. Small Price electric meter. Purchased November 12, 1896; rated December 10, 1896, at Kensington station, Md., by C. C. Babb and E. G. Paul.

Rating tables made in 1896 for current meters.

Revolutions per second.	Velocities in feet per second.										
	No. 16.	No. 25 H. P.	No. 25 L. P.	No. 27 H. P.	No. 27 L. P.	No. 63.	No. 67.	No. 68.	No. 69.	No. 70.	No. 91.
0.00	0.27	0.67	1.01	0.63	0.70	0.40	0.25	0.20	0.25	0.20	0.10
.10	.33	.73	1.12	.70	.83	.63	.45	.51	.53	.35	.25
.20	.42	.80	1.23	.76	.96	.91	.72	.81	.81	.65	.51
.30	.49	.86	1.35	.82	1.09	1.19	1.00	1.12	1.09	.97	.77
.40	.57	.93	1.46	.90	1.27	1.47	1.30	1.42	1.37	1.26	1.03
.50	.69	1.03	1.58	.99	1.44	1.75	1.60	1.73	1.65	1.55	1.29
.60	.80	1.13	1.72	1.07	1.61	2.03	1.90	2.04	1.93	1.85	1.55
.70	.92	1.23	1.87	1.15	1.79	2.31	2.19	2.36	2.21	2.14	1.81
.80	1.04	1.34	2.01	1.25	1.98	2.59	2.48	2.67	2.49	2.44	2.07
.90	1.16	1.44	2.16	1.33	2.19	2.87	2.77	2.98	2.77	2.73	2.33
1.00	1.28	1.55	2.33	1.42	2.40	3.15	3.06	3.29	3.04	3.03	2.59
1.10	1.40	1.65	2.50	1.51	2.62	3.43	3.35	3.59	3.32	3.33	2.85
1.20	1.52	1.75	2.68	1.60	2.83	3.71	3.64	3.90	3.60	3.62	3.11
1.30	1.64	1.85	2.86	1.69	3.04	3.99	3.93	4.19	3.88	3.92	3.37
1.40	1.76	1.95	3.03	1.77	3.25	4.27	4.23	4.48	4.16	4.22	3.63
1.50	1.88	2.05	3.19	1.86	3.46	4.55	4.53	4.77	4.44	4.51	3.90
1.60	2.00	2.15	3.36	1.97	3.67	4.83	4.82	5.06	4.72	4.81	4.16
1.70	2.12	2.26	3.54	2.07	3.88	5.11	5.11	5.36	5.00	5.11	4.42
1.80	2.24	2.36	3.72	2.18	4.09	5.39	5.40	5.65	5.28	5.40	4.68
1.90	2.36	2.48	3.90	2.29	4.30	5.67	5.70	5.94	5.56	5.70	4.94
2.00	2.48	2.59	4.07	2.39	4.51	5.95	6.00	6.23	5.84	6.00	5.20
2.10	2.60	2.71	4.24	2.49	4.72	6.23	6.29	6.52	6.12	6.29	5.63
2.20	2.72	2.83	4.42	2.60	4.93	6.51	6.58	6.81	6.40	6.58	6.07
2.30	2.84	2.95	4.59	2.71	5.14	6.79	6.87	7.10	6.68	6.88	6.50
2.40	2.96	3.07	4.77	2.81	5.35	7.07	7.17	7.39	6.96	7.17	7.00
2.50	3.08	3.19	4.95	2.92	5.56	7.35	7.47	7.68	7.24	7.46	8.80
2.60	3.20	3.31	5.13	3.02	5.77	7.63	7.77	7.97	7.52	7.76	10.30
2.70	3.32	3.43	5.31	3.12	5.98	7.91	8.06	8.26	7.80	8.05	11.60
2.80	3.44	3.55	5.49	3.23	6.18	8.19	8.36	8.55	8.08	8.34	.....
2.90	3.56	3.67	5.67	3.34	6.39	8.47	8.65	8.85	8.37	8.63	.....
3.00	3.68	3.79	5.85	3.44	6.61	8.75	8.95	9.13	8.65	8.92	.....
3.10	3.80	3.91	6.02	3.56	6.82	9.03	9.24	9.42	8.94	9.21	.....
3.20	3.92	4.03	6.20	3.66	7.03	9.31	9.53	9.71	9.22	9.50	.....
3.30	4.04	4.15	6.38	3.77	7.24	9.59	9.82	10.00	9.51	9.80	.....
3.40	4.16	4.26	6.56	3.88	7.45	9.87	10.11	10.29	9.80	10.10	.....
3.50	4.28	4.38	6.74	3.98	7.66	10.15	10.41	10.59	10.10	10.39	.....
3.60	4.40	4.50	6.92	4.09	7.87	10.43	10.70	10.89	.....	10.68	.....
3.70	4.52	4.62	7.09	4.19	8.08	10.71	10.99	.....	.....	10.98	.....
3.80	4.64	4.74	7.27	4.30	.....	10.99	11.28	.....	.....	11.28	.....
3.90	4.76	4.86	7.44	4.40	.....	11.27	11.57	.....	.....	11.57	.....
4.00	4.88	4.98	7.61	4.51	.....	11.55	11.87	.....	.....	11.86	.....
4.10	5.00	5.10	7.79	4.62	.....	11.83	12.17	.....	.....	.....	.....
4.20	5.12	5.22	7.97	4.73	.....	12.11	12.46	.....	.....	.....	.....
4.30	5.24	5.34	8.14	4.83	.....	12.39	12.76	.....	.....	.....	.....
4.40	5.36	5.46	8.31	4.93	.....	12.67	13.05	.....	.....	.....	.....
4.50	5.48	5.58	8.49	5.04	.....	12.95	13.35	.....	.....	.....	.....
4.60	5.60	5.70	8.67	5.14	.....	13.23	.....	.....	.....	.....	.....
4.70	5.72	5.81	8.85	5.24	.....	13.51	.....	.....	.....	.....	.....
4.80	5.84	5.92	9.03	5.34	.....	13.79	.....	.....	.....	.....	.....
4.90	5.96	6.04	.....	5.45	.....	14.07	.....	.....	.....	.....	.....
5.00	6.08	6.16	.....	5.55	.....	14.35	.....	.....	.....	.....	.....

DRAINAGE AREA MEASUREMENTS.[1]

		Square miles.
American Fork near American Fork, Utah		66
Animas River at Durango, Colorado		812
Arkansas River, East Fork, near Leadville, Colorado		44
Arkansas River, Lake Fork, near Leadville, Colorado		21
Arkansas River, Tennessee Fork		44
Arkansas River at Granite, Colorado		425
Arkansas River at Salida (above South Fork)		1,160
Arkansas River at Canyon City, Colorado		3,060
Arkansas River at Swallows, Colorado		4,300
Arkansas River at Pueblo, Colorado		4,600
Arkansas River at La Junta, Colorado (including Fountain Creek drainage, 1,011 square miles)		12,200
Arkansas River at railroad bridge above Holly, Colorado (including Animas River, 7,333 square miles)		23,500
Arkansas River at Colorado-Kansas State line		24,600
Arkansas River at Hutchinson, Kansas		34,000
Bear Creek at Morrison, Colorado		170
Bear River at Battle Creek, Idaho		4,500
Bear River at Collinston, Utah		6,000
Bear River at Soda Springs, Idaho		3,940
Black Warrior River at Tuscaloosa, Alabama		4,900
Blacks Fork, 3 miles west of Granger, Wyoming		1,747
Boise River at Boise, Idaho		2,450
Boise River at Caldwell, Idaho		3,360
Boulder Creek, South, at South Boulder Canyon, near Marshall, Colorado		125
Boulder Creek, North, at Boulder, Colorado		179
Boulder Creek, near Boulder, Colorado		102
Blue River in Kansas	2,450	
Blue River in Nebraska	7,040	
		9,490
Broad River at Gaffney, South Carolina		1,435
Broad River at Alston, South Carolina		4,609
Bruneau River at Grand View, Idaho		1,800
Cache la Poudre River above Fort Collins, Colorado		1,060
Caliente Creek:		
Tehachapi Creek	108	
Caliente Creek proper	219	
Basin Creek	96	
		423
Canadian River in Kansas	5,110	
Canadian River in New Mexico	16,900	
Canadian River in Texas	18,620	
		40,630
Cape Fear River at Fayetteville, North Carolina		4,493
Carson River, east, at Rodenbahs, Nevada		414
Carson River, west, at Woodford, California		70
Carson River near Empire, Nevada		894
Catawba River at Catawba, South Carolina		3,492
Catawba River at Fort Mill, South Carolina		2,987
Chama River at Abiquiu, New Mexico		2,300
Chattahoochee at Oakdale, Georgia		1,560
Chattahoochee at Westpoint, Georgia		3,300
Chowchilla Creek above sec. 1, T. 9 S., R. 18 E.		268
Cimarron at Arkalon, Kansas		5,200
Clear Creek, 4 miles west of Buffalo, Wyoming		118
Clear Creek near Granite, Colorado		72
Colorado River in Arizona[2]	56,182	
Colorado River in California	8,610	
Colorado River in Colorado	5,490	
Colorado River in Nevada	3,200	
Colorado River in New Mexico	19,000	
Colorado River in Utah	21,633	
		114,115

[1] A number of the drainage areas not given in this table are to be found on pages 107 to 110 of the Eleventh Annual Report, Part II.

[2] Thirteenth Ann. Rept., Part III, p. 33; area in square miles of principal drainage basins, by States.

		Square miles.
Colorado River at Yuma, Arizona		225,049
Columbia River in Oregon[1]		24,093
Columbia River in Idaho[1]	7,880	
Columbia River in Montana	25,000	
Columbia River in Washington	26,160	
		59,040
Connecticut River at Hartford, Connecticut		10,234
Coosa River at Riverside, Alabama		6,850
Coosawattee River at Carters, Georgia		532
Cottonwood Creek, South Fork, near Buena Vista, Colorado		28
Cottonwood Creek, Middle Fork, near Buena Vista, Colorado		37
Dan River at Clarksville, Virginia		3,798
Dolores River at Dolores, Colorado		562
Elkhorn River at Norfolk, Nebraska		2,474
Etowah River at Canton, Georgia		573
Falls River, 5 miles above mouth, Idaho		594
Fort Tejon Creek, including Cuddy Creek and Castac Lake (upper basin, 56)		93
French Broad River at Asheville, North Carolina		987
Frenchman River at Wauneta, Nebraska		989
Frenchman River at Palisade, Nebraska		1,032
Gallatin River at Logan, Montana		1,620
Gila River at Buttes, Arizona		13,750
Gila River, including small lost basins, in Arizona[1]	56,838	
Gila River, including small lost basins, in New Mexico	14,300	
		71,138
Goose Creek, Big, at Sheridan, Wyoming, below mouth of Little Goose Creek		320
Goose Creek, Little, at Sheridan, Wyoming		128
Grand River at Glenwood Springs, Colorado		5,838
Grand River at Grand Junction, above Gunnison River, Colorado		8,644
Grand River at Grand Junction, below Gunnison River (including, above Uncompahgre, 497 square miles, and Gunnison, at mouth, 7,935 square miles)		16,579
Grand River in Colorado[1]	22,294	
Grand River in Utah	3,873	
		26,167
Great Basin in California[1]	47,240	
Great Basin in Idaho	3,420	
Great Basin in Nevada	102,220	
Great Basin in Oregon	18,950	
Great Basin in Utah	43,548	
Great Basin in Wyoming	1,494	
		216,872
Green River at Green River, Wyoming		7,450
Green River at Blake, Utah		38,200
Green River in Colorado[1]	10,332	
Green River in Utah	15,916	
Green River in Wyoming	20,977	
		47,225
Greenbrier River at Alderson, West Virginia		1,344
Greenbrier River at mouth, West Virginia		1,575
Gunnison River at Grand Junction, Colorado		7,935
Gunpowder River at Baltimore Conduit, Maryland		294
Henry Fork, 1 mile above mouth of Falls River, Idaho		931
Hiwassee River at Murphy, North Carolina		410
Humboldt River at Elko, Nevada		2,840
Humboldt River at Battle Mountain, Nevada		7,800
Humboldt River at Golconda, Nevada		10,780
Humboldt River (including Grassy Valley) at Oreana, Nevada		14,967
Humboldt River, South Fork, at Masons Ranch, Nevada		536
James River, South, at mouth, Virginia		116
James River, North, at East Glasgow, Virginia		831
James River at Buchanan, Virginia		2,058
James River at Balcony Falls, Virginia		3,027
Jefferson River at Sappington, Montana		8,984
Jefferson River at Three Forks, Montana		9,400
Jones Falls at Baltimore Conduit, Maryland		38
Kansas River at Lecompton, Kansas		58,554
Kansas River at Lawrence, Kansas		59,841

[1] Thirteenth Ann. Rept., Part III, p. 33; area in square miles of principal drainage basins, by States.

		Square miles.
Kansas River in Kansas	34,526	
Kansas River in Nebraska	17,455	
Kansas River in Colorado	9,459	
		61,440
Kaweah River above sec. 3, T. 18 S., R. 27 E., California		619
Kern River at first point of measurement above Bakersfield, California, including—		
North Fork	1,115	
South Fork	1,050	
Lower Basin	180	
		2,345
Kings River		1,742
Laramie River above Woods Landing, Wyoming (in Colorado, 343)		435
Laramie River at Uva, Wyoming (including in Colorado, 428)		3,179
Laramie River at mouth at Fort Laramie (not including 500 square miles of lost drainage to James Lake, Cooper Lake, etc.)		4,076
Logan River at Logan, Utah		218
Loup River, Middle, at St. Paul, Nebraska		6,849
Loup River, North, at St. Paul, Nebraska		4,024
Loup River at Columbus, Nebraska		13,542
Madison River at Redbluff, Montana		2,085
Madison River at Threeforks, Montana		2,402
Malad River at Taponis, Idaho		2,190
Malheur River at Vale, Oregon		9,900
Medicine River at Kiowa, Kansas		1,300
Merced River above Merced Falls, California		1,076
Middle Creek near Bozeman, Montana		55
Mississippi River at St. Paul, Minnesota (Minnesota River, 16,350)		36,085
Missouri River at Townsend, Montana		14,500
Missouri River at Canyon Ferry, Montana		15,036
Missouri River at Craig, Montana		17,615
Missouri River above Yellowstone, in Montana[1]	81,018	
Missouri River above Yellowstone, in Wyoming	760	
		81,778
Monocacy River at Frederick, Maryland		665
Nantahalah River at mouth, North Carolina		193
Natches River at North Yakima, Washington		1,000
Neosho River at Iola, Kansas		3,670
Neuse River at Selma, North Carolina		1,175
New River at Greenbrier River, West Virginia		4,523
New River at Hinton, West Virginia		5,600
New River at Fayette, West Virginia		6,200
North Platte River above Sweetwater (including in Colorado, 1696)		7,668
North Platte River above Douglas, Wyoming		14,255
North Platte River above Orin Junction, Wyoming		14,828
North Platte River above Fort Laramie, Wyoming		16,416
North Platte River below Laramie River, Wyoming		20,492
North Platte River in Wyoming and Colorado		23,643
North Platte River at Camp Clark, Nebraska		24,225
North Platte River to North Platte, Nebraska		28,517
Ocmulgee River at Macon, Georgia		2,425
Oconee River at Carey, Georgia		1,346
Ogden River at Powder Mills, Utah		360
Oostenaula River at Resaca, Georgia		1,527
Owyhee River at Ontario, Oregon		9,875
Patapsco River at Woodstock, Maryland		251
Patuxent River at Laurel, Maryland		137
Payette River at Payette, Idaho		3,565
Piedras River at Arboles, Colorado		650
Platte River at North Platte:		
North Platte River	28,517	
South Platte River	23,294	
		51,811
Platte River at Columbus, Nebraska		56,867
Platte River, North and South, in Colorado[1]	22,230	
Platte River in Nebraska	10,850	
Platte River in Wyoming	24,240	
		57,320

[1] Thirteenth Ann. Rept., Part III, p. 33; area in square miles of principal drainage basins, by States.

		Square miles.
Portneuf River at McCammon, Idaho		500
Potomac River, North Branch, above Bloomington, Maryland		293
Potomac River, North Branch, at Piedmont, West Virginia (including Savage Creek, 111)		409
Potomac River, North Branch, at Cumberland, Maryland (including New Creek, at mouth, at Keyser, West Virginia, 56)		891
Potomac River, North Branch, at junction with South Branch (including Patterson Creek at Burlington, below Mill Creek, 155, and at mouth, 279)		1,365
Potomac River, South Branch, at junction with North Fork (including at Franklin, 188)		318
Potomac River, South Branch, including North Fork (including North Fork below Seneca Creek, 240, and at mouth, 322)		640
Potomac River, South Branch, at Moorefield, West Virginia (including Mill Creek at mouth, 101)		897
Potomac River, South Branch, below Moorefield (including South Fork at Fort Seybert, West Virginia, 155, and at mouth at Moorefield, 301)		1,198
Potomac River, South Branch, at Romney, West Virginia		1,407
Potomac River, South Branch, at United States Geological Survey station at railway bridge, between Romney and Springfield, West Virginia		1,443
Potomac River, South Branch, at mouth		1,487
Potomac River at junction of North and South branches		2,852
Potomac River above Great Cacapon River (including Little Cacapon River, 117)		3,388
Potomac River below Great Cacapon River (including Great Cacapon above North River, 404, and at mouth, 671)		4,059
Potomac River at Hancock, West Virginia		4,099
Potomac River at Williamsport, Maryland (including Warm Spring Creek at mouth, 16; Conoloway Creek, 125; Sleepy Creek, 146; Licking Creek, 195; Back Creek, 288, and Conocheague Creek, 579)		5,556
Potomac River at Harpers Ferry, West Virginia (including Opequon Creek, 335; Antietam Creek, 305)		6,354
Potomac River below Harpers Ferry, West Virginia (including Shenandoah River, 3,009)		9,363
Potomac River at Weverton, Maryland		9,397
Potomac River at Point of Rocks, Maryland		9,654
Potomac River at Edwards Ferry, below Goose Creek (including Monocacy River at mouth, 941, and Goose Creek, 384)		11,100
Potomac River at Great Falls, Maryland (including Seneca Creek, 132)		11,427
Potomac River at Chain Bridge, District of Columbia		11,545
Prosser Creek at Boca, California		55
Provo River at Provo, Utah		640
Purgatoire River at Trinidad, Colorado		742
Purgatoire River at Las Animas, Colorado		3,040
Red Rock Creek at Redrock, Montana		1,330
Republican River, North Fork, at Haigler, Nebraska		1,390
Republican River at Superior, Nebraska		22,347
Republican River at Junction City, Kansas		25,837
Republican River in Colorado	7,926	
Republican River in Nebraska	10,415	
Republican River in Kansas	7,496	
		25,837
Rio Grande at Del Norte, Colorado		1,400
Rio Grande at Embudo, New Mexico		7,000
Rio Grande at Rio Grande, New Mexico		11,250
Rio Grande at El Paso, Texas		30,000
Rio Grande in Colorado[1]	7,527	
Rio Grande in New Mexico (including Pecos River)	72,380	
Rio Grande in Texas	80,550	
		160,457
Roanoke River at Roanoke, Virginia		388
Roanoke River at Clarksville, Virginia		7,344
Roanoke River at Neal, North Carolina		8,717
Rock Creek at Battle Mountain, Nevada		725
Rock Creek, Little, at Palmdale, California		78
Sacramento River at Jellys Ferry, California		9,134
Sacramento River above Redbluff, California		9,356

[1] Thirteenth Ann. Rept., Part III, p. 33; area in square miles of principal drainage basins, by States.

		Square miles.
Sacramento and San Joaquin rivers in California	63,020	
Sacramento River	655	
		63,675
Salt River below Tonto Creek, Arizona		5,756
Salt River in canyon 20 miles above Verde		5,880
Salt River at Arizona Dam, Arizona		12,260
Saline River at Beverly, Kansas		2,730
Saline River at mouth, Kansas		3,311
Saluda River at Waterloo, South Carolina		1,056
San Emidio Creek, California		54
San Gabriel River in canyon above Azusa, California		220
San Joaquin River above Hamptonville, California		1,637
San Juan River at Arboles, Colorado		1,394
San Miguel River at Seymour, Colorado		327
San Pedro River at Dudleyville, Arizona		2,870
Santa Ana River at Warm Springs, Colorado		184
Savannah River below Rocky River, at Calhoun Falls, South Carolina, above Beaverdam Creek		2,712
Savannah River above Augusta, Georgia		7,294
Sevier River at Leamington, Utah		5,595
Shenandoah River (North Fork) at Brocks Gap, Virginia		215
Shenandoah River (North Fork) at Mount Jackson, Virginia		511
Shenandoah River (North Fork) at Riverton, Virginia		1,037
Shenandoah River (South Fork) at Port Republic, Virginia (including Middle River to junction with North River, 363; North River to junction with Middle River, 418; to junction with South River, 804; South River to junction with North River, 246)		1,050
Shenandoah River (South Fork) at Milnes, Virginia		1,288
Shenandoah River (South Fork) at Overall, Virginia		1,491
Shenandoah River (South Fork) at mouth at Riverton, Virginia		1,587
Shenandoah River at Riverton, Virginia (including North Fork, 1,037, and South Fork, 1,587)		2,624
Shenandoah River at Millville, West Virginia		2,995
Shenandoah River at mouth at Harpers Ferry, West Virginia		3,009
Shoshone River at Corbett, Wyoming		1,718
Shoshone River, South Fork, at Marquette, Wyoming		500
Smoky Hill River at Ellsworth, Kansas (including in Colorado 1,533, in Kansas 6,447)		7,980
Smoky Hill River below Ellsworth, exclusive of Saline and Solomon rivers		2,255
Smoky Hill River at mouth at Junction City, Kansas		20,428
Snake River, North Fork, at Ferry, Idaho		931
Snake River at Idaho Falls, Idaho		10,100
Snake River at Montgomery Ferry, Idaho		22,600
Snake River in Idaho[1]	73,500	
Snake River in Nevada	5,280	
Snake River in Oregon	17,950	
Snake River in Washington	6,682	
Snake River in Wyoming	5,268	
		108,680
Solomon River at Beloit, Kansas		5,539
Solomon River at mouth, Kansas		6,882
South River at Port Republic, Virginia		1,050
South Platte River at Deansbury, Colorado		2,600
South Platte River at Denver, Colorado (including Bear Creek at Morrison, 170)		3,840
South Platte River at Greeley, Colorado, above mouth of Cache la Poudre River		7,110
South Platte River below Greeley, Colorado		9,575
South Platte River at Orchard, Colorado		12,260
South Platte River at mouth at North Platte River, Nebraska		23,294
Spanish Fork near Spanish Fork, Utah		670
Spokane River at Spokane, Washington		4,005
St. Vrain Creek near Lyons, Colorado		209
Stanislaus River at Oakdale, California		1,051
Staunton River at Clarksville, Virginia		3,546
Sun River at Augusta, Montana		1,175

[1] Thirteenth Ann. Rept., Part III, p. 33; area in square miles of principal drainage basins, by States.

		Square miles.
Sweetwater River (Wyoming) at mouth		2,929
Sweetwater River at Sweetwater Dam, California		186
Tar River at Tarboro, North Carolina		2,290
Tejon House Creek at Tejon Ranch House, Kern County, California		17
Tennessee River, Little, at Judson, North Carolina		682
Teton River at Wilford, Idaho		967
Thompson Creek near Loveland, Colorado		305
Tongue River at Miles, Montana		3,875
Truckee (Little) River at Boca, California		186
Truckee River at Boca, California		887
Truckee River at Tahoe, California		550
Truckee River near Essex, Nevada		991
Truckee River near Laughtons, Nevada		1,054
Truckee River near Vista, Nevada		1,519
Tuckaseegee River 3 miles above Bryson, North Carolina		609
Tule River above Portersville, California		437
Tuolumne River above Roberts Ferry, California, at foothills		1,501
Tuolumne River at Modesto		1,635
Twin Lake Creek below Twinlakes, Colorado		102
Umatilla River at Gibbon, Oregon		353
Umatilla River at Pendleton, Oregon		640
Uncompahgre River at Fort Crawford, Colorado		497
Verde River 1 mile above Salt River		6,000
Verdigris River at Independence, Kansas		3,067
Weber River at Uinta, Utah		1,600
Weiser River at Weiser, Idaho		1,670
West Gallatin River above Salesville, Montana		860
White River at White River City, Colorado		1,773
Wood River at Hailey, Idaho		906
Wood River, Little, at Taponis, Idaho		1,270
Yadkin River at Holtsburg, North Carolina		3,399
Yadkin River at Norwood, North Carolina		4,614
Yakima River at Union Gap, Washington (of this, Tiaton, 330)		3,300
Yakima River at Kiona, Washington		5,230
Yellowstone River at Horr, Montana		2,700
Yellowstone River in Montana[1]	36,312	
Yellowstone River in North Dakota	250	
Yellowstone River in Wyoming	33,121	
		69,683

[1] Thirteenth Ann. Rept., Part III, p. 33; area in square miles of principal drainage basins, by States.

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DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 12

UNDERGROUND WATERS OF A PORTION OF SOUTHEASTERN NEBRASKA.—DARTON

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

IRRIGATION REPORTS.

The following list contains titles and brief descriptions of the principal reports relating to water supply and irrigation prepared by the United States Geological Survey since 1890:

1890.

First Annual Report of the United States Irrigation Survey, 1890; octavo, 123 pp.

Printed as Part II, Irrigation, of the Tenth Annual Report of the United States Geological Survey, 1888-89. Contains a statement of the origin of the Irrigation Survey, a preliminary report on the organization and prosecution of the survey of the arid lands for purposes of irrigation, and report of work done during 1890.

1891.

Second Annual Report of the United States Irrigation Survey, 1891; octavo, 395 pp.

Published as Part II, Irrigation, of the Eleventh Annual Report of the United States Geological Survey, 1889-90. Contains a description of the hydrography of the arid region and of the engineering operations carried on by the Irrigation Survey during 1890; also the statement of the Director of the Survey to the House Committee on Irrigation, and other papers, including a bibliography of irrigation literature. Illustrated by 29 plates and 4 figures.

Third Annual Report of the United States Irrigation Survey, 1891; octavo, 576 pp.

Printed as Part II of the Twelfth Annual Report of the United States Geological Survey, 1890-91. Contains "Report upon the location and survey of reservoir sites during the fiscal year ended June 30, 1891," by A. H. Thompson; "Hydrography of the arid regions," by F. H. Newell; "Irrigation in India," by Herbert M. Wilson. Illustrated by 93 plates and 190 figures.

Bulletins of the Eleventh Census of the United States upon irrigation, prepared by F. H. Newell; quarto.

No. 35, Irrigation in Arizona; No. 60, Irrigation in New Mexico; No. 85, Irrigation in Utah; No. 107, Irrigation in Wyoming; No. 153, Irrigation in Montana; No. 157, Irrigation in Idaho; No. 163, Irrigation in Nevada; No. 178, Irrigation in Oregon; No. 193, Artesian wells for irrigation; No. 198, Irrigation in Washington.

1892.

Irrigation of western United States, by F. H. Newell; extra census bulletin No. 23, September 9, 1892; quarto, 22 pp.

Contains tabulations showing the total number, average size, etc., of irrigated holdings, the total area and average size of irrigated farms in the subhumid regions, the percentage of number of farms irrigated, character of crops, value of irrigated lands, the average cost of irrigation, the investment and profits, together with a résumé of the water supply and a description of irrigation by artesian wells. Illustrated by colored maps showing the location and relative extent of the irrigated areas.

1893.

Thirteenth Annual Report of the United States Geological Survey, 1891-92, Part III, Irrigation, 1893; octavo, 486 pp.

Consists of three papers: "Water supply for irrigation," by F. H. Newell; "American irrigation engineering" and "Engineering results of the Irrigation Survey," by Herbert M. Wilson; "Construction of topographic maps and selection and survey of reservoir sites," by A. H. Thompson. Illustrated by 77 plates and 119 figures.

A geological reconnoissance in central Washington, by Israel Cook Russell, 1893; octavo, 108 pp., 15 plates. Bulletin No. 108 of the United States Geological Survey; price, 15 cents.

Contains a description of the examination of the geologic structure in and adjacent to the drainage basin of Yakima River and the great plains of the Columbia to the east of this area, with special reference to the occurrence of artesian waters.

1894.

Report on agriculture by irrigation in the western part of the United States at the Eleventh Census, 1890, by F. H. Newell, 1894; quarto, 283 pp.

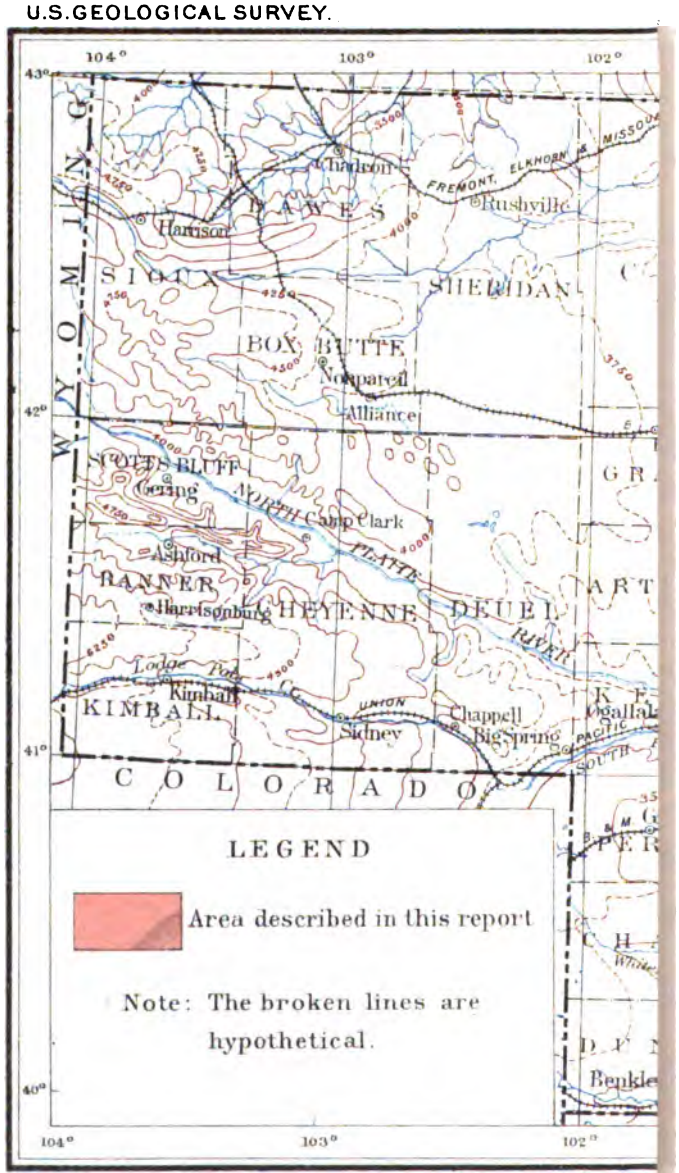
Consists of a general description of the condition of irrigation in the United States, the area irrigated, cost of works, their value and profits; also describes the water supply, the value of water, of artesian wells, reservoirs, and other details; then takes up each State and Territory in order, giving a general description of the condition of agriculture by irrigation, and discusses the physical conditions and local peculiarities in each county.

Fourteenth Annual Report of the United States Geological Survey, 1892-93, in two parts; Part II, Accompanying papers, 1894; octavo, 597 pp.

Contains papers on "Potable waters of the eastern United States," by W. J. McGee; "Natural mineral waters of the United States," by A. C. Peale; "Results of stream measurements," by F. H. Newell. Illustrated by maps and diagrams.

(Continued on third page of cover.)

U.S.GEOLOGICAL SURVEY.



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DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 12

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

UNDERGROUND WATERS

OF

A PORTION OF SOUTHEASTERN NEBRASKA

BY

NELSON HORATIO DARTON

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, June 14, 1897.

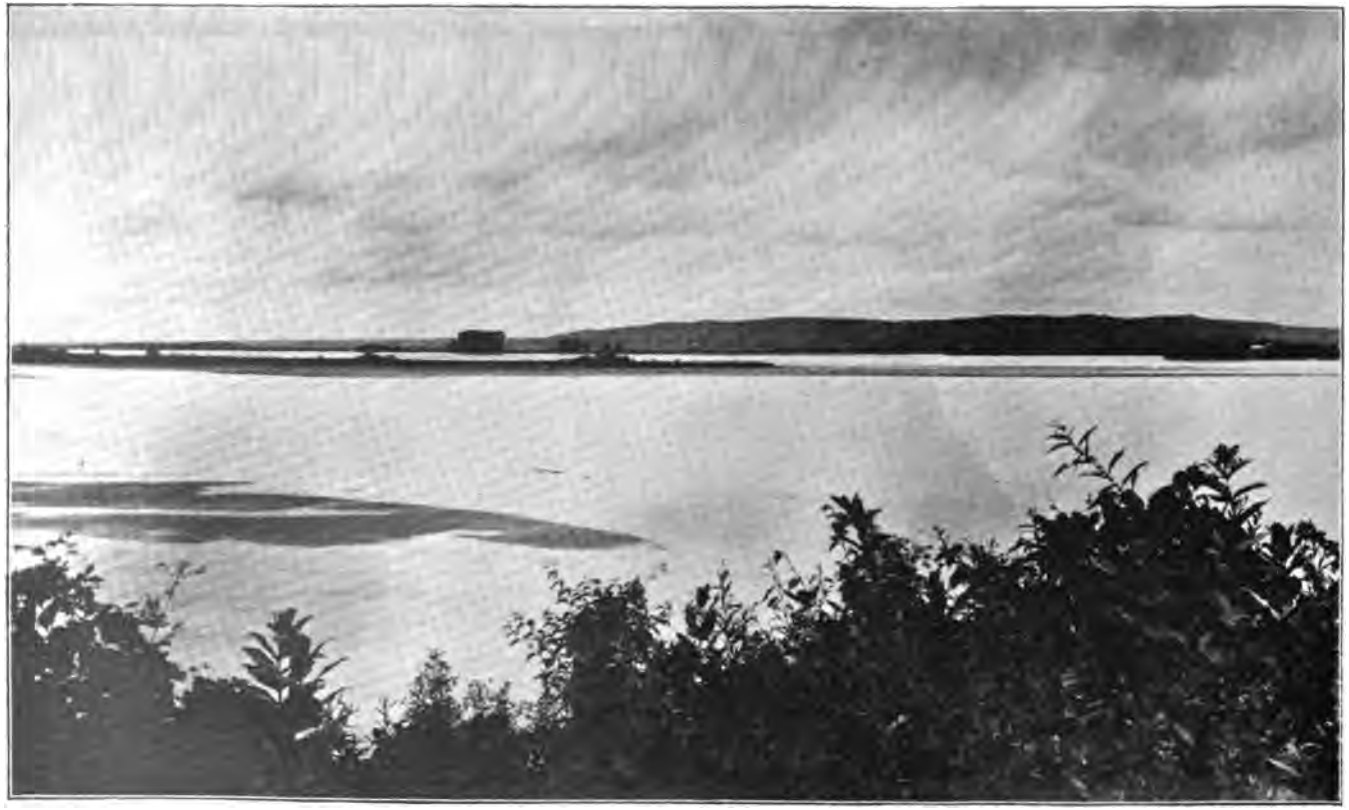
SIR: I have the honor to transmit herewith a manuscript prepared by Mr. N. H. Darton, assistant geologist of this Survey, relating to the underground or well waters of a portion of the State of Nebraska. The facts given are the results of field work in this State during the season of 1896. Beginning in the vicinity of Lincoln, Nebraska, Mr. Darton not only made a detailed examination of the surface geology, but carried on a careful search for all wells, both shallow and deep. As far as possible, information was obtained concerning the depth of the wells, the character of the strata penetrated, and the volume and quality of the water supply. This work was conducted westward to the vicinity of Lexington. In this work Mr. Darton was assisted by Mr. Joseph E. Macfarland, a young man whose untimely death at the end of the field season deprived the Survey of the services of one of its most promising and energetic junior geologists.

To a discussion of the geologic formations and their water contents Mr. Darton has appended a statement as to the possibility of obtaining artesian water, adding such facts as were procurable concerning the utilization of the available water supply in irrigation. In this particular area agriculture is not regarded as dependent, to any considerable extent, upon the artificial application of water, but the examples cited show that in many localities irrigation on a small scale can be employed with profit. It is proposed during the coming field season to extend this investigation westward into the areas where the necessity for irrigation has long been recognized and where water supplies have a still greater value. The field work is confined largely to the areas of which topographic maps have been prepared, as without such maps studies of underground waters are necessarily vague and inconclusive.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.



PLATTE RIVER NEAR ASHLAND, NEBRASKA, SHOWING STREAM DEPOSITS.

UNDERGROUND WATERS OF A PORTION OF SOUTHEASTERN NEBRASKA.

By NELSON HORATIO DARTON.

INTRODUCTION.

This report relates to underground waters in Lancaster, Seward, northern Saline, York, Fillmore, Hamilton, Clay, Hall, Adams, Buffalo, Kearney, Phelps, northern Gosper, and eastern and central Dawson counties, an area of about 6,700 square miles.[1] It is the result of observations made with the assistance of Messrs. J. E. Macfarland and C. A. Fisher in the summer and autumn of 1896. It deals mainly with waters occurring at moderate depths, but also briefly reviews the probabilities of obtaining water supplies from deeper-seated sources.

The region is one in which the average annual rainfall is not sufficient to insure full crops every season, even in the eastern part of the area, where the rainfall is considerably greater than in the western counties. Fortunately, very nearly all of this region is underlain by water-bearing deposits, which in most districts yield good supplies of water to pump wells. The depth to this water varies from less than 10 feet in the valley of Platte River to somewhat over 300 feet in the higher plateau areas of Dawson and Gosper counties and in a few instances in the high drift hills of Lancaster County. The supply is also variable in amount, but in most cases the average windmill does not lower its level. The waters have been used to some extent for irrigation, and the results have been entirely satisfactory, so far as the crops are concerned. In most cases a single windmill has not proved adequate to supply water for the irrigation of over 15 acres, under the most favorable conditions, and in the deeper wells, or where the water is more scanty in supply, the limitations are greater. This acreage is, however, sufficient for the cultivation of a profitable diversified crop, large enough at least to carry a family over a dry season. It is not the purpose of this report to discuss the efficacy of

[1] The greater part of this area is covered by topographic atlas sheets of the Survey, as follows: *Lincoln*, York, *Grand Island*, *Wood River*, *Kearney*, and *Lexington*, of which those in italics are now ready for sale at 5 cents each.

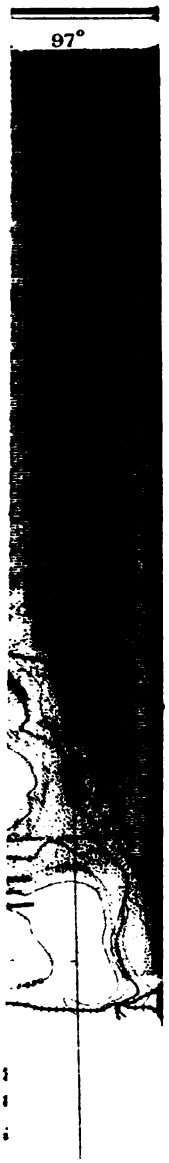
windmills, which it is believed can be greatly increased, nor the prospects for irrigation in the district. The location and extent of the underground water will be set forth mainly by maps, which will also give information in regard to the conditions of its occurrence.

TOPOGRAPHY OF THE DISTRICT.

The region to which this report relates lies on the eastern slope of the Great Plains which extend from the Rocky Mountains toward the Mississippi River. It comprises several types of land forms. The greater part of the area is a smooth plain, sloping gently eastward from an altitude of 2,700 feet near the one hundredth meridian to about 1,400 feet in the vicinity of the ninety-seventh meridian—a slope of about 7 feet to the mile. Westward this plain is widely trenched by the broad valley of Platte River, which lies from 80 to 160 feet below the plains surface. There are also other valleys of moderate width, of which the largest are those of the Big and Little Blue rivers and their branches, South Fork of Loup River, Wood River, and Plum Creek. To the east, in eastern Seward and Lancaster counties, the smooth plains give place to a region of high drift hills, deeply intersected by wide valleys. Another characteristic feature of the region is the sand-dune areas, mainly along the south side of the valleys of Platte and Loup rivers.

The valley of Platte River is 20 miles wide in Hall County, but it narrows considerably toward the west. East of Kearney, where it is also occupied by Wood River, a branch of Platte River, the valley is 12 miles wide. At Kearney the width rapidly diminishes to 8 miles, and this width continues some miles westward. In Dawson County the valley widens to 15 miles. The floor of the valley of Platte River is a very smooth plain, sloping gently toward the east. The river flows in channels but slightly depressed below the valley floor, and in dry seasons the water meanders through these channels in small ramifying rivulets, with intervening sand banks of various sizes. The character of these sand banks is shown in Pl. II.

There are some islands which are submerged only in times of high water; the principal one, known as Grand Island, has a length of 42 miles and owes its isolation to a narrow channel which passes around its northwestern side. The river usually does not occupy the center of the valley, but has a general disposition to hug its south side. In Hamilton County the principal channel is at the bottom of the slope which rises to the higher plain. East of longitude 99° 30′ the valley of Platte River is depressed from 80 to 100 feet below the surface of the adjoining plains, but the depth gradually increases in Dawson County to over 150 feet. Wood River has a level-floored valley, which merges into that of the Platte just north of Kearney. The South Fork of Loup River flows in a valley which averages about a mile in width in the northern part of Buffalo County.



avium

some pebbly beds)
both mostly cov-

In Seward, Saline, York, Fillmore, Hamilton, Clay, Adams, Kearney, and eastern Phelps counties the plains present very broad areas of smooth surface, and often extend uninterruptedly for many miles. They are, however, more or less deeply trenched by the branches of Big and Little Blue rivers, and toward the west, where the land rises higher above the adjoining valleys, the plains are very much cut up by small branch brooklets, so that much of the higher region of Buffalo, Dawson, and Gosper counties consists of narrow ridges, usually with steep slopes, separated by numerous narrow valleys. In Gosper County these valleys assume a canyon type, particularly along the steep slope on the south side of the Platte Valley and in the slopes extending southward toward the Republican Valley.

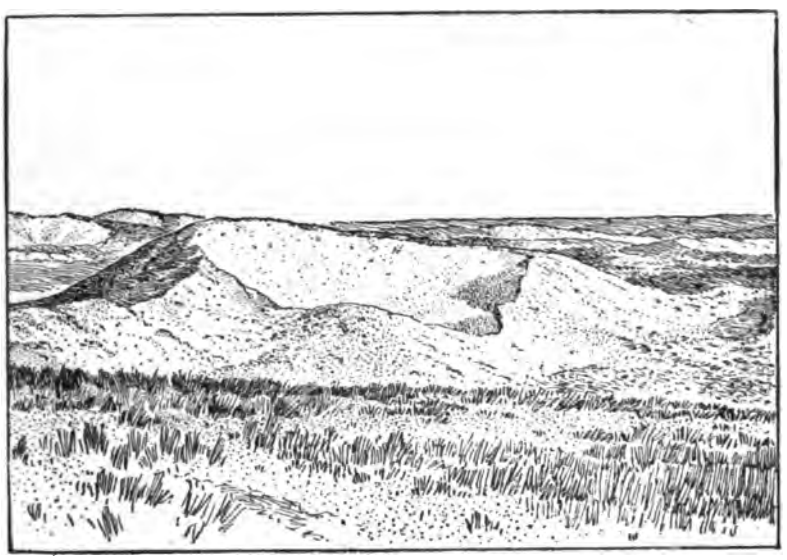


FIG. 1.—Typical sand dune with "blow-out" in its top.

In the drift-hill region of Lancaster and adjoining counties another type of topography is presented. There are high, rolling hills in long, irregular ridges separated by wide, level-floored valleys, of which the Salt Creek Valley with its branches is the most extensive. Lincoln is built at a confluence of a number of branches of Salt Creek and along the adjoining slopes of the drift hills. The drift surface rises to an altitude of about 1,550 feet in the eastern portion of Seward County, but the altitude to which the higher summits rise eastward gradually diminishes to from 1,300 to 1,400 feet in the eastern portion of Lancaster County. The bottom of the valley in which Lincoln is situated has an altitude of about 1,150 feet.

Areas of sand dunes are very frequent in the Platte and Loup valleys in Hall, Buffalo, Adams, Kearney, and Phelps counties. Some smaller areas also occur in Dawson County and on the high plains

and slopes about the head waters of Little Blue River in western Adams and eastern Kearney counties. The areas are characterized by their irregular, hummocky contour and loose sand surfaces. Some of the higher mounds rise 100 feet above the adjacent lowlands and are conspicuous features in the landscape. There are many basins among the hills and meandering valleys which have no outlets. The largest bodies of the sand extend for 50 miles along the south side of the Platte Valley south of Kearney, lying mainly against the slope which rises to the higher plains. There are also extensive deposits south of the South Fork of Loup River in northern Buffalo and Hall counties. The width of the wider portions of these sand-dune belts is about 3 miles. A "blow-out," a characteristic feature in some of the sand-dune areas, is shown in fig. 1 (p. 13.)

GEOLOGY.

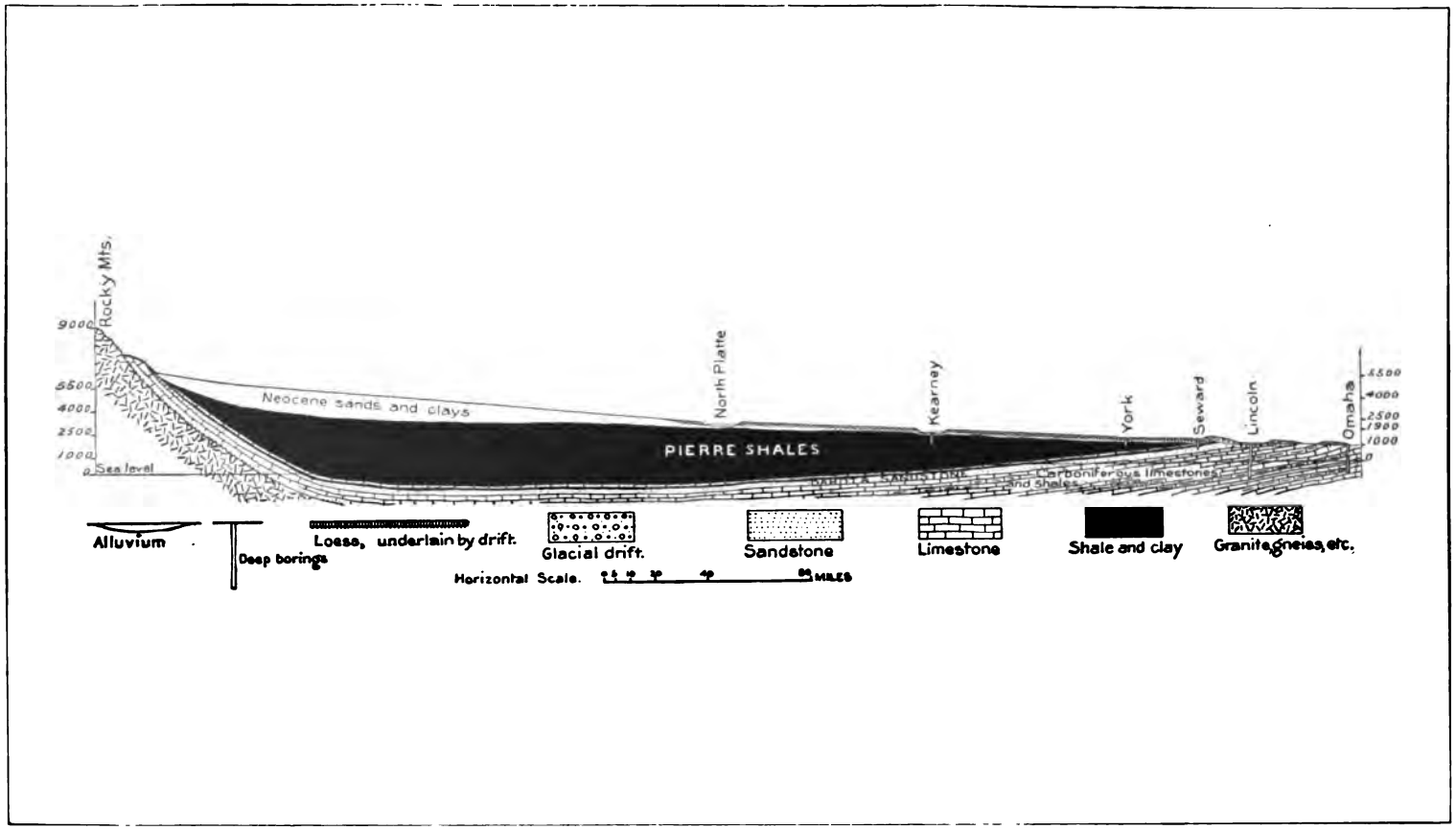
GENERAL STRUCTURE.

Southeastern Nebraska is underlain by Carboniferous and Cretaceous formations bearing a superficial mantle of Pleistocene deposits. The older formations have a gentle slope toward the west, and the overlying deposits are in general conformable to the eastward slope of the land. In Pl. IV is given a cross section from the Rocky Mountains to the Missouri River at Omaha, showing the general structural relations.

East of the longitude of Lincoln the limestone and associated rocks of the Carboniferous formation reach the surface, and they are frequently exposed in the valleys in the southeastern corner of the State. Toward the west their gentle dip and the rapid rise of the land carry them far beneath the surface, so that in the vicinity of the ninety-ninth meridian they appear to lie at a depth greater than 3,000 feet. Farther westward they may or may not increase in depth, but they rise in approaching the Rocky Mountains and outcrop high on the slopes of these mountains in Colorado and Wyoming.

The series of Cretaceous formations which lie on the Carboniferous beds comprises the Dakota sandstone, the Benton shales, the Niobrara limestone, and the Pierre shales. The lowest member, the Dakota sandstone, reaches the surface, to the eastward, in a zone which passes near Lincoln.

In the slopes of the Rocky Mountains the Dakota sandstone is separated from the Carboniferous beds by the Juratrias red sandstones, sands, and clay, which probably extend for some distance eastward, no doubt under the western portion of Nebraska, but they do not reach the surface in the eastern portion of the State. A characteristic exposure of these beds on the eastern slope of the Rocky Mountains is given in Pl. V. Near the ninety-seventh meridian the Dakota sandstone passes under the thin series of Benton shales and Niobrara limestones, and these in turn soon disappear beneath a mass



SECTION FROM THE ROCKY MOUNTAINS ACROSS WYOMING AND NEBRASKA.

of Pierre shales, which attain a thickness of over 3,500 feet under the central and western portion of the State. The Carboniferous and Cretaceous formations in the eastern part of the State are heavily overlain by Pleistocene deposits, comprising a large mass of glacial drift and a thick mantling of loess. West of longitude 98° 30′ there intervenes between the Pleistocene deposits and the Cretaceous formations a series of Neocene deposits, which gradually thicken toward the west, and finally, rising above the slope on which the loess lies, become the dominant surface formations in the western portion of the State. The glacial drift is a thick mass in Lancaster County. It thins rapidly toward Missouri River and westward, its attenuated margin passing under a thick sheet of loess in both directions. Toward the west the larger mass of glacial drift presents an obscure morainal front along the eastern side of Seward County, from which a continuous thick mantle of loess extends far westward. Under this loess mantle there is a thin sheet of drift materials extending out from the front of glacial drift. West of latitude 98° 30′ a thin wedge of calcareous

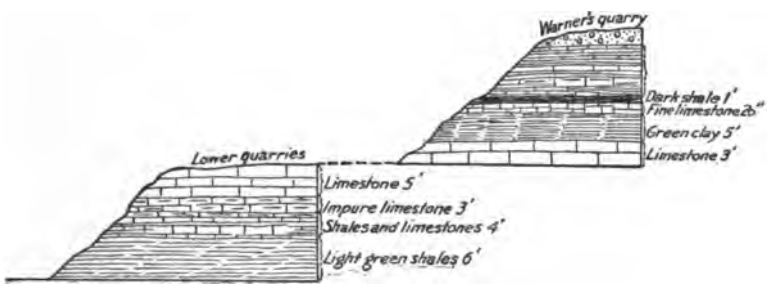


FIG. 2.—Section of Carboniferous beds in quarries near Roca, Nebraska.

and siliceous sediments, of Neocene age, comes in between the loess and drift and the Pierre shale surface, gradually thickening toward the west. The loess mantle is widely trenched by the valley of Platte River and more or less deeply excavated by the other valleys, which are often cut through to the underlying Pleistocene and Neocene formations.

The loess has a thickness of from 60 to 90 feet in greater part. Flooring the large depressions that traverse the region are deposits of alluvial formations, which are of great width along Platte River. In some portions of the area there are accumulations of dune sands of greater or less extent, and these, aside from sand banks in the rivers, are the most recent formations of the region.

THE FORMATIONS.

Carboniferous.—Carboniferous limestones reach the surface in southern, central, and eastern Lancaster County. They consist of a variety of limestone beds with intercalated shales and clays. The principal exposures are in the vicinity of Roca, near Hickman, and

about Bennett. At these localities the rocks have been quarried, notably about Roca, where they have furnished large amounts of fine building stone. A columnar section of the rocks at Roca is given in fig. 2 (p. 15), which comprises all the members exposed in the quarry just north of Roca station and in the Warner quarries and depressions a mile north of the village.

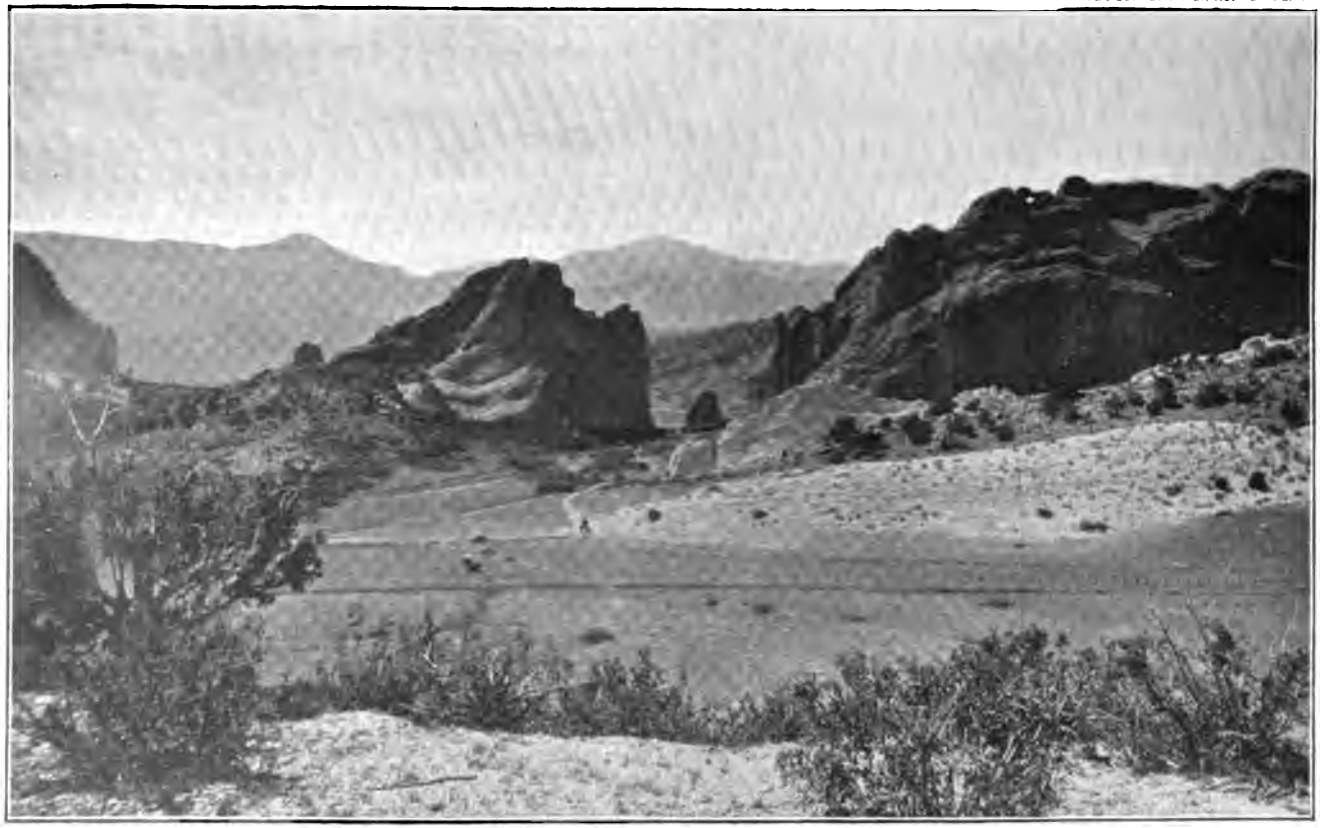
From the beds in Warner's quarry Mr. Macfarland collected the following fossils:

Euomphalus rugosus.	P. cora.
Setopora biserialis?	P. nebrascensis.
Marginifera splendens.	Chonetes flemingi.
Spirifer cameratus.	C. granulifera.
Meekella striatocostata.	Fusilina cylindrica.
Seminula subtilita.	Amboccelia planoconvexa.
Derbya crassa.	Orthis (Rhipidomella) carbonaria.
Rhombopora lepidodendroides.	Pugnax uta.
Productus semireticularis.	Orbiculoida sp.

At Bennett some different members of the formation are exposed, and so far it has not been possible to ascertain the relative positions of the rocks of the two areas. Probably in the region between Roca and Bennett and toward the south the Carboniferous beds are not far beneath the surface in the deeper hollows, but they are covered by the general heavy drift mantling. In the deep borings at Lincoln the Carboniferous beds were penetrated to a depth of over 1,000 feet. They appear to begin at a depth of about 269 feet. The section given in fig. 7, page 29, illustrates the general succession of deposits.[1]

Dakota sandstone.—In eastern Nebraska the Carboniferous formations are overlain directly by the Dakota sandstone, without trace of the Juratrias deposits intervening. At a point a mile and a half due north of Roca station the contact may be seen; at Bennett the two formations are in immediate proximity; and in the wells at Lincoln the contact lies about 269 feet beneath the surface. A finely exposed contact is shown in Pl. VI. The contact line between the Dakota sandstone and the Carboniferous beds in eastern Nebraska presents many steep slopes, indicating an irregular shore line against which Dakota sediments were deposited. The materials of the Dakota formation are mainly gray and brown sandstone, but there are also intercalated clays of various colors. Portions of the sandstone are highly ferruginous, so much so as to be frequently mistaken for iron ore. The sandy character of the formation is, however, prominent throughout. Where the amount of iron is large the rock is very apt to have a highly concretionary structure. The coarser sandy members are usually cross bedded. A characteristic outcrop is shown in Pl. VII. The texture of the sandstone varies irregularly from

[1] A more detailed description of the beds is given by Mr. B. P. Russell in the Sixth Biennial Report of the Commissioner of Public Lands and Buildings to the Governor of Nebraska, 1888, pp. 57-84. Lincoln, 1888.



JURATRIAS RED SANDSTONES, SANDS, ETC., AT ENTRANCE TO GARDEN OF THE GODS, NEAR MANITOU, COLORADO.

rock which is quite firm to sand which is hardly consolidated. In most cases the material is a soft sandstone which can be easily excavated with the pick. Some of the firmer beds contain fossil leaves in considerable abundance.

In the region covered by this report the exposures of Dakota sandstone are confined to Lancaster County and the vicinity of Pleasantdale in eastern Seward County. They occur at intervals along the sides of depressions of branches of Salt Creek, and at Bennett at the head of the Little Nemaha River. They are mainly very small and quite widely scattered, and are due chiefly to the excavation of depressions which have been cut through the glacial drift. Their location is shown in Pl. III (p. 12). In some cases belts of exposures mark the presence of a ridge of Dakota sandstone under the drift. The most extensive outcrops occur at intervals along and near the Burlington and Missouri River Railroad from Lincoln nearly to Roca, on the western slope of the ridge on the east side of Southeast Salt Creek. There are quite extensive exposures about the penitentiary and in the vicinity of the Chicago, Rock Island and Pacific Railroad crossing. Just east of Saltillo gray sandstones appear halfway up the slope, and they are again exposed on the point of the next ridge 2 miles farther south, lying against the Carboniferous limestone. The brown sandstones appear on Antelope Creek in the southeastern corner of Lincoln, as shown in Pl. VIII, at the "cave" in the southern margin of the city, and at the crossing of the Chicago, Rock Island and Pacific Railroad and Burlington and Missouri River Railroad, Nebraska City branch. Between Emerald and Pleasantdale the Dakota sandstone rises as a moderately high ridge under the drift and is exposed in a number of railroad and stream cuts. The beds are extensively cross bedded, and in some of the exposures consist of a highly ferruginous sandstone with complex concretionary structure. There are several exposures on both slopes of Haines Branch Valley and along the hollow beginning 2 miles southwest of Rokeby. They are of the usual brown sandstone. At the brick and tile works a mile southwest of the insane asylum the formation is represented by clays mainly of mottled pink, brown, and gray colors, with streaks of sand and sandstone and a bed of dark-gray clay containing a large amount of organic material. The clays have been mined extensively at this place for brick and tile, for which they appear well suited. They are overlain by a small amount of drift and a considerable mass of fossiliferous loess. Some of the features of this exposure are shown in Pls. XIV and XV.

There is another excavation in a similar mass of clay in the southern edge of West Lincoln, just east of the lake. The exposures of Dakota sandstone north of Lincoln are along Little Salt Creek and some of its branches south and southwest of Davey, along Rock Creek north of Waverly, and in depressions along the head branches of Rock

Creek northeast of Davey. In all of these exposures there is seen brown sandstone, excepting in the railroad cut northeast of Davey, where a mottled clay is exposed. The only exposures discovered east of Lincoln are in a small branch of Stevens Creek 6½ miles east of the Lincoln post-office, at an old quarry in the north side of Stevens Creek a mile and half above its mouth, and in the hollow just north of the railroad a mile west of Prairie Home. The exposure of the Dakota sandstone just south of Bennett, at the head of the Little Nemaha River, is very interesting. The formation consists of quite regular beds, from 1 foot to 2 feet in thickness, of beautifully cross-bedded sands hardly sufficiently cemented together to be classed as sandstone. The exposure is across a depression from limestone, as shown in fig. 3. The relations indicate that probably there was here a steep shore of the limestone during the deposition of the Dakota sandstone, although possibly the two formations are separated by a fault. In Pls. IX and X there are reproduced photographs of portions of the exposure, showing the cross bedding very clearly. In Pl. IX the overlying glacial drift is also shown.

FIG. 3.—Cross section at Bennett, Nebraska; looking north.

The Dakota sandstone has been reported in many of the wells in Lancaster County, and in fact it is one of the principal sources of water supply in the deeper wells.

In the boring made by the State near Lincoln in 1886 the lower portion of the Dakota formation was penetrated. According to Mr. B. P. Russell,[1] the materials covering the Carboniferous limestone were as follows:

Feet.	
0 - 4	.....Sandy loam.
4 - 20	.....Angular greenish sand.
20 - 24¾	.....Coarser whitish sand.
24¾ - 48¼	.....Coarse gravel.
48¼ - 52	.....Sand, whitish, even grained, in part rounded.
52 - 57	.....Coarse gravel.
57 - 74	.....Fine yellow sand.
74 -100	.....Lighter sand.
100 -112¾	.....Coarser, dark-yellow sand; gravel and iron pebbles.
112¾ -133¾	.....White sand and gravel, with brine at 119 feet.
133¾ -135	.....Yellowish-white sand.
135 -147¾	.....Yellow sand; small pebbles.

[1] Sixth Biennial Report of the Commissioner of Public Lands and Buildings, December 1, 1888, pp. 65-68. A slightly different record is given in the Fifth Report, 1886, p. 19.

DAKOTA SANDSTONE LYING ON CARBONIFEROUS LIMESTONE, WEST BANK OF MISSOURI RIVER, AT MOUTH OF PLATTE RIVER.

(The arrows indicate the plane of contact.)

DAKOTA SANDSTONE ON WEST BANK OF MISSOURI RIVER, AT MOUTH OF PLATTE RIVER.

Shows cross bedding and beds of coarse materials.

Feet.		
147¾ -164¼	Coarse yellow sand and gravel.	
164¼ -179¾	Yellow sand.	
179¾ -195	White sand; gravel.	
195 -202	Very coarse gravel.	Containing brine 85°; strong flow.
202 -205	Coarse gravel and conglomerates.	
205 -206¼	Coarse conglomerate with chalky, flinty pebbles.	
206¼ -208¾	Soft gray sandstone.	
208¾ -209¼	Reddish clay.	
209¼ -214¼	Light-drab clay.	
214¼ -244¼	Fine-grained, gray, very soft sandstone.	
244¼ -247¼	Greenish-drab clay.	
247¼ -267 1/12	Fine-grained, reddish, very soft sandstone.	
267 1/12-269 1/12	Arenaceous gray clay lying on chert, shale, and limestone.	

It is thought that the top of the Dakota formation was entered at a depth of 48¼ feet, but the evidence is by no means conclusive.

From the data of wells and outcrops in the Lincoln region it has been possible to prepare a map (Pl. XX) with contour lines showing the altitude of the surface of the Dakota sandstone under a portion of Lancaster County and adjoining area. These lines are intended to indicate the contour of the sandstone surface on which the drift deposits lie. An endeavor has also been made to differentiate the valleys cut into the sandstone in areas from which the drift has been removed, as, for instance, along the center of the Salt Creek and Southeast Salt Creek valleys. A further explanation of the relations is shown by cross sections in Pl. XXI. The irregularities of contour are probably mainly due to preglacial erosion, but there is some evidence that the elevated area about Pleasantdale is due in part to an upward arching of the beds.

In Pl. XVII the depth of the Dakota sandstone below the surface is shown for each 50 feet, as a guide to the contained water supply.

Benton and Niobrara formations.—The Benton formation, in its typical development, consists of dark shale lying conformably on the surface of the Dakota sandstone. Owing to the heavy drift and loess covers in the region in which the Benton formation should be expected to reach the surface, only one exposure of that formation has been found. This is in the bed of Big Blue River just below Milford, where a few inches of black shales of supposed Benton age are to be seen under the Niobrara beds. As it was not possible to obtain evidence as to the depth at which the Dakota sandstone lies in this vicinity, no definite statement can be made of the thickness of the Benton deposits, but it is thought they will prove to be less than 100 feet thick. The boring at Seward, of which a record is shown in fig. 8, page 31, found 100 feet of dark clay lying between "sand and gravel" and the top of the supposed Dakota beds. If the "sand and gravel" are drillings from Niobrara beds, which is probable, the underlying clay would be Benton. The probable location of the eastern margin of the formation is shown in Pl. XX.

The Niobrara formation is represented by impure siliceous limestones, which outcrop at a number of points in the eastern and southern part of Seward and Saline counties. The beds are usually thin, but owing to their hardness and the ease with which they can be quarried, they have been employed to some extent for foundation and other rough work. There are some quarries near Pleasant Hill, along the west side of the North Fork of Turkey Creek, on the east bank of Big Blue River 4 miles north of Crete, and in the upper portion of the valley of Middle Oak Creek, northeast of Germantown. The formation is also exposed for some distance along Beaver Creek near the southern margin of Seward County, and along Big Blue River just below Milford, notably in a small branch just south of the Soldiers' Home at Milford, as shown in Pl. XI; and it is said to appear in the bed of Big Blue River in the vicinity of Camden.

The rock is characterized by impressions of the fossil oyster known as *Inoceramus labiatus* and possibly some other species. In some of the beds, also, we may expect to find the characteristic fossil *Ostrea congesta*. The general aspect of these fossils is shown in the two figures on Pl. XII. These fossils are here figured because it is very important to be able to distinguish them from the Carboniferous fossils in the limestone which underlies the Dakota sandstone. Their occurrence is a guide to the progress of a deep boring west of longitude 97°, for the water-bearing Dakota beds may be expected in regular order below. The thickness of the Niobrara formation can not be definitely stated, as none of the exposures were complete, and we have no well records which are sufficiently definite to afford a basis for precise estimation. It is believed, however, that the formation will not prove to be over 40 or 50 feet in thickness, and probably it is considerably less.

Pierre shales.—This formation consists of a great mass of shales, predominantly dark gray in color, which thicken rapidly westward under central and western Nebraska. Owing to the heavy mantle of loess and drift, and, to the west, of Neocene deposits, there are no exposures of these shales at the surface. They have, however, been deeply penetrated by a number of well borings. At Kearney it is claimed that they are over 2,500 feet thick; at Hastings they extend from 224 feet to 1,346½ feet; at Dannebrog they extend from 135 feet to 1,011 feet, and at York they were penetrated for several hundred feet. It is probable that the thickness is 4,000 feet under the western portion of the State, as shown in Pl. IV, but the actual amount is not known. The shales contain occasional thin beds of sand, iron pyrites, and heavy dark clay.

Neocene formations.—The representatives of the Neocene formations which are so prominent in the western portions of Nebraska are found underlying the Pleistocene deposits in the central portion of the State, where their thickness gradually decreases until finally they thin out entirely.

EXPOSURE OF DAKOTA SANDSTONE ON ANTELOPE CREEK, IN SOUTHEASTERN PORTION OF LINCOLN, NEBRASKA.

Also shows glacial drift.

The materials consist of siliceous and calcareous sediments, mainly of a sandy texture and chalky aspect. They are often called "magnesia." Portions of the beds are light-colored, very sandy clays containing chalk-like nodules. The eastern margin of these deposits has not been definitely located in the area to which this report relates. South of the South Fork of Loup River there is no evidence of their existence east of longitude 98° 30′, but north of that river they may extend somewhat farther east. They are exposed in depressions northeast of Kearney, and from thence westward in Buffalo, Dawson, Phelps, and Gosper counties, where many of the deeper canyons cut into them. Owing to the manner in which the loess rolls down or caves along the slopes of the wider depressions, exposures are relatively rare, and so far it has not proved practicable to map the Neocene formations very satisfactorily, owing to their being thus concealed for long intervals in depressions in which they might otherwise be expected to outcrop. To the west the exposures increase in abundance and a greater thickness of the formation is exposed. The most extensive exposures in the area to which this report relates are along the upper portions of Plum Creek.

Earlier Pleistocene deposits.—These deposits comprise a mass of glacial drift in Lancaster and eastern Seward counties, and a thin sheet of gravelly sand, which extends far westward under the loess mantle of the plains region, and appears to be contemporaneous with the glacial drift. The glacial drift constitutes a very irregular mass of bowlder clays, sands, gravels, and bowlder beds, covering the greater part of Lancaster County. It constitutes high hills, which are traversed by the deep, wide valleys of Salt Creek and its branches in the region about Lincoln. The glacial drift ends toward the west in the slope which descends quite steeply to Big Blue River from Seward southward. Its precise western limit could not be definitely determined owing to the overlapping of loess and the frequent lack of distinctive outcrops. The greater portion of the glacial drift consists of blue and gray bowlder clays. There are also beds of blue and gray clay nearly pure or containing a little mixture of fine sand, but scattered bowlders of pebbles occur almost everywhere through it. There are included sand beds, ordinarily containing bowlders, but locally quite free from them, and numerous lenses of bowlder beds, consisting mainly of bowlders. The pink Sioux quartzite, often in very large masses, is a conspicuous feature of the drift, but there are many other rocks associated. Wide areas of clay surface with only a few scattered bowlders occur, and other areas of light-colored sandy clays, particularly on the higher, level lands, which appear to be loess merging into the glacial drift. A characteristic bowldery surface is shown in Pl. XIII.

No order of succession has yet been determined for the glacial deposits. Instructive exposures are very rare, and well records have

thrown but little light on the relations. In fig. 4 is given a sketch of some features exposed on the Chicago, Rock Island and Pacific Railroad cut near Prairie Home, in Lancaster County.

The central mass is an oxidized, ferruginous clay of brownish-buff color, with scattered pebbles and soft calcareous concretions. The overlying sheet of bowlders contains many masses of pink Sioux quartzite, mainly angular, with some fragments of other crystalline rocks. This is overlain by pinkish sandy clay, with a few pebbles, mostly of small size. On the top is a mantle of pale-buff loam, with ferruginous and calcareous concretions somewhat like loess in aspect, but more argillaceous and lacking the typical texture.

The thin drift sheet which extends far westward from the glacial-drift margin, under the loess, underlies a wide area of central Nebraska. It is usually a thin sheet of sandy clay, commonly of pinkish color. Eastward it becomes more sandy, thickens, and is often represented by coarse sand. Pebbles of a great variety of rocks of Rocky Mountain origin occur, both in the pink sandy clays and in the more sandy portions to the east. These pebbles are characteristic of the deposit as far westward as I have traced it, which is in the vicinity of Ogal-

FIG. 4.—Glacial formations in cut one-quarter mile west of Prairie Home station; looking north.

lala. The precise relation of this formation to the glacial drift can not be ascertained in the area examined, but it appears to merge into glacial-drift deposits in eastern Seward County.

The loess.—The loess is a great mantle of light buff-colored loam, which constitutes the surface of the plains of south-central Nebraska over thousands of square miles. It abuts against and overlaps the thick mass of glacial drift to the east in eastern Seward County, but extends westward in a vast tabular surface. From the eastward there is a lower-level phase which extends up the depressions of Salt Creek and Little Nemaha River, but does not reach an altitude much above 1,250 feet in the Lincoln region. The most extensive development of the formation is in the wide plains west of Big Blue River, where it covers all of the surface between the large drainage depressions. A wide trench is cut through the formation by the valley of Platte River, and many smaller streams have cut through or deeply into it.

In the upland portions of Buffalo, Dawson, and Gosper counties the surface is deeply invaded by numerous small valleys, which become steep-sided canyons as the land rises to the west, particularly in Gosper County.

DAKOTA SANDSTONE OVERLAIN BY GLACIAL DRIFT, NEAR BENNETT, NEBRASKA.
(LOOKING WEST.)
Shows cross bedding.

DAKOTA SAND IN QUARRY JUST SOUTHEAST OF BENNETT, NEBRASKA.

Shows regular and cross bedding.

The materials of the loess consist of fine sandy loam, somewhat calcareous, and chiefly of a pale brownish-yellow color. Occasionally a streak of sand is found, and some portions are slightly more argillaceous than usual. The material is of remarkably uniform texture, compact, but perfectly soft. Water falling upon its surface is absorbed in some measure, but on steep slopes the material is rapidly excavated wherever a rivulet gets a fair start.

In the lower part of the formation, possibly underlying it and entirely separate, are deposits of volcanic ash, usually mixed with more or less fine sand, but often so pure as to be of brilliant white color, and consisting almost entirely of fine shreds of volcanic glass. The purer material is very serviceable as a polishing powder. The occurrence of this volcanic-ash deposit has been reported at two localities within the area, but owing to lack of knowledge as to the conditions under which it occurs, no description of it will here be offered.

The loess is generally fossiliferous, containing scattered fossils of quite a variety of species, often represented by numerous individuals. These fossils were found throughout the area represented as loess in Pl. III. It also contains calcareous concretions, especially toward the east. An outcrop of loess in Salt Creek Valley is shown in Pl. XV.

Alluvium.—The wider, deeper valleys are floored with alluvial deposits which have been brought from greater or less distances by the streams now occupying these valleys. Along the smaller drainage ways the materials are of such local origin that it has not always been possible to differentiate them satisfactorily, but in the larger valleys they are well-defined alluvial accumulations of considerable thickness. The most notable deposits are those in the wide valley of Platte River, which has a width of 20 miles at Grand Island, 12 miles at Kearney, and 15 miles at Lexington, and is floored to a considerable depth with alluvial deposits.

Along the South Fork of Loup River and Wood River there are also narrower alluvial deposits, which are confluent with those of the Platte Valley. There are deposits also along Little Blue River, Big Blue River and its branches, and in the depression of Salt Creek and its branches.

A large amount of the alluvial deposits consists of loess-like material containing streaks of clay and gravel, but usually lacking the loess texture and fossils. In the immediate vicinity of Platte River, along its channel and islands, the deposits are mainly coarse sands with more or less gravel, but there are extensive admixtures of loam and some clay. In the valley of Salt Creek the material is largely loess-like, but there is also a great deal of dark mud, and this is in greater part the characteristic which is presented along Big Blue River and its larger branches.

Dune sands.—The area to which this report relates lies southeast of the great sand-hill region of Nebraska, but it includes a number of

small local sand-dune areas. The largest of these extends along the south side of the Platte Valley from opposite Elm Creek to opposite Wood River. There are several small dune areas along the south side of the valley of the South Fork of Loup River near Sartoria and Pleasanton, and the southern extremity of an extensive area is found just west of Cairo. There are some small detached areas of dune sands southwest of Kenesaw, in Adams County, and south and southwest of Holstein, in the same county, and in the eastern part of Kearney County. These dune sands are wind blown and derived mainly from alluvial deposits of the river bottom, which have traveled along the valley and accumulated where changes in the trend of the valley were favorable for stopping them, or where some minor obstructions arrested their progress. The belt south of Kearney has a width of about 5 miles where it is widest.

The sands lie on the pebbly or sandy floor of the river bottom, but are usually banked up against the edge of the loess upland, and in some places extend up onto the plains surfaces. The dunes present great varieties of form, cones, ridges, mounds, and basins being the most general. Over much of the area there is no movement of the sand, and the surface is covered with sod. There are, however, many bare places from which the sand is traveling. In windy weather more or less sand is blown all over the region, and loose sand is mixed with the soil of the loess plain adjoining, usually for some distance from the margin of the sand-dune area. A characteristic sand dune is portrayed in fig. 1, on page 13.

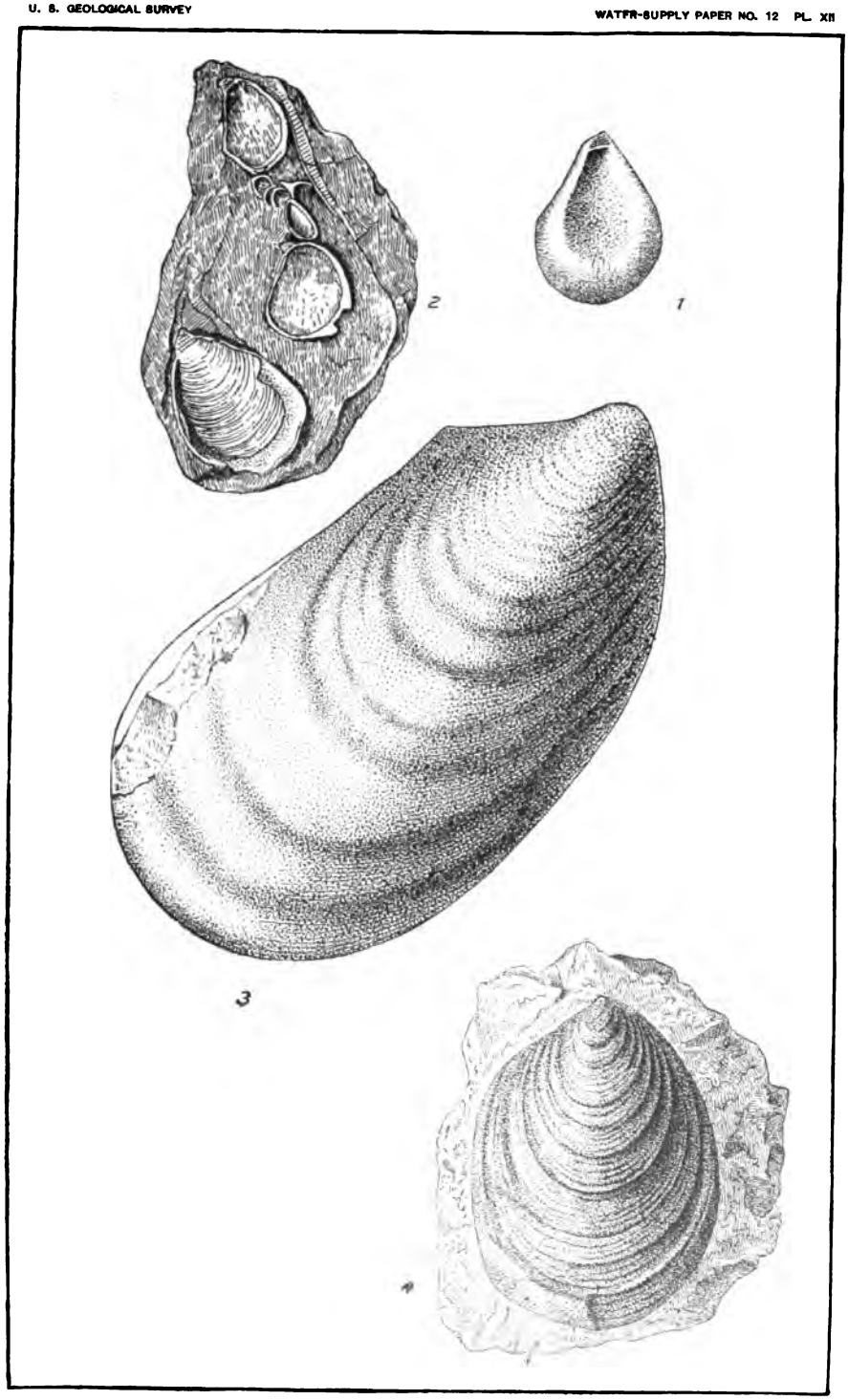
THE WATER HORIZONS.

The underground waters of southern-central Nebraska occur in several geologic horizons. In the region west of Big Blue River the various beds of coarse material lying between the loess and the Pierre shales afford a general water supply which is of large volume at nearly all localities. The eastern edge of the Neocene deposits and the drift sands which lie just below loess are the principal reservoirs of these waters.

In the wide valley of Platte River nearly all of the coarser materials, especially the basal beds of the alluvium and the coarser portions of the alluvium near the stream, are filled with water, which is obtainable from shallow wells. Although in dry weather the Platte River shows very little water at the surface, just below the dry sand and shingle in its bed there is a sheet of water which extends widely under the alluvial flat on either side. These permeable alluvial materials and more or less underlying coarse material of Neocene and Pleistocene age contain a large aggregate supply of water.

As the valley of Platte River is somewhat higher than the adjoining valleys of the branches of Blue, Republican, and Loup rivers, the waters that lie in its bottom flow out laterally through the coarse mate-

NIOBRARA LIMESTONE ON COON CREEK, IN SOUTHERN PORTION OF MILFORD, NEBRASKA. (LOOKING NORTH.)



TYPICAL FOSSILS OF NIOBRARA LIMESTONE.

Ostrea congesta Conrad. { Fig 1. Interior view of the upper valve, slightly enlarged (after Meek).
Fig. 2. Three small lower valves attached to the shell of a large Inoceramus (after Meek).

Inoceramus labiatus Schloth. { Fig 3 Right valve of an elongated specimen (after Meek).
Fig 4. Small right valve with unusually strong concentric ridges

rial underlying the loess and issue as springs or underground seepage in these deeper depressions. In the vicinity of Grand Island the evidence is very clear that the Platte waters pass under the loess-covered divide and emerge in the deep valleys of the head waters of branches of Big Blue River, which are considerably lower in altitude than the bottom of the Platte Valley. There is also underground leakage to the north into the depression containing the South Fork of Loup River. This is very clearly shown at Kearney, where, in a series of gage wells sunk for the Division of Hydrography, the water level is shown to gradually decline to the northwest a very appreciable amount within the city limits of Kearney, as shown by fig. 12, on page 40. The wells in the valleys and high lands northward show a continued diminution in altitude of the water surface, which indicates an underground flow to the north. There is excellent evidence that under Phelps and Kearney counties there is underflow from Platte River toward the Republican Valley. This underflow is rendered possible by the pervious nature of the great sheet of materials which lies between the loess and the top of the impervious Pierre shales. These conditions are illustrated in fig. 5.

FIG. 5.—Ideal section showing the usual relations of underground waters in the central plains region of Nebraska.

The valley on the left is that of Platte River, and the depression on the right is similar to the depressions of the branches of Big and Little Blue, Republican, and Loup rivers. The rate of this underflow is exceedingly slow, for careful experiments have shown that underground water moving through sands, even if the sands are relatively coarse, does not progress over a mile or two a year.

As the water-bearing beds under the loess thicken westward, their upper portions rise higher above the bottom of the Platte Valley in western Dawson and Gosper counties, and it is usually found necessary to go to considerable depth in them to find sufficient water supply.

Some of the exceptional relations which are often found locally in the region west of the ninety-eighth meridian are illustrated in the cross sections in Pl. XVIII. In section *A* there is shown a condition which is quite frequent in Buffalo and Dawson counties. A well at B has to go to the general underflow in the water-bearing bed A A; but at C, at much less depth, a local water supply of greater or less volume is found in a shallow basin underlain by clay. In section *B* a condition is illustrated which is found in some of the shallower valleys on the high loess plains. Here the underflow conditions are continued

under a valley without interruption, and the beds yield water to wells at G G. They are also reached by wells at E and F, but at E a water supply may be obtained from the gravels flooring the valley bottom. In section *C* are shown the relations of two water-bearing sands separated by a bed of clay. In some areas both horizons are drawn on for water, and either one may contain the greater amount. Ordinarily the deepest wells obtain the largest supplies of water, but in other cases the largest volumes are in the upper bed of sand containing the underflow from the river valleys. A well at H would find abundant supplies of water in the gravels and sands flooring the valley.

Section *D* illustrates a relation which may account for some observed inequalities in the volume of water in the same bed of sand on either side of a river valley. A well at J would yield a good supply of water, but one at K would yield less because the water escapes into the river bottom on the one side and a local deposit of clay seals off the entrance of a continued underflow on the other side of the valley toward K.

Section *E* illustrates a change of material from coarse to fine—pervious to impervious—in the same bed. Thus, a well at L would

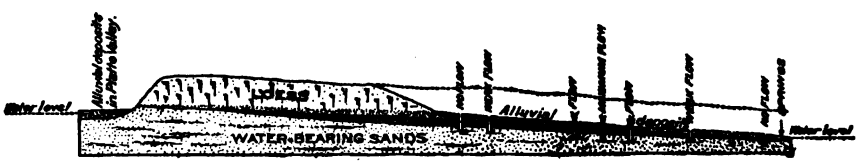


FIG. 6.—Ideal section from the Platte Valley to and down the valley of West Blue River, to show the probable cause of the flow.

obtain a water supply from sands which merge into clay toward M, where the clay would have to be penetrated to underlying sands at greater depth.

The geologic relations of the water-bearing stratum in the Beaver Crossing region are not as yet fully ascertained. The waters lie in sands which are overlain by a heavy bed of tough, impervious clay, but the depths are so moderate that it can hardly be thought that these sands are of the Dakota formation. It is much more probable they are in the western extension of the drift deposits. The head is due to the elevation of the intake area of the waters westward, and it is sustained locally through the protection afforded by a wide extent of the overlying mantle of tough, impervious clay. In fig. 6 is given an ideal section to show the probable relation. This should be compared with the section in fig. 5 (p. 25), which shows the usual conditions in other areas where there is no flow.

In Lancaster and eastern Seward counties the principal supplies of underground waters occur in the Dakota sandstone and sands. In the drift deposits waters are often abundant in supply and satisfactory in quality, but their occurrence is so exceedingly irregular that

TYPICAL STONY DRIFT SURFACE, NORTHERN LANCASTER COUNTY, NEBRASKA.

no definite idea could be formed as to their relations. A large number of wells have been sunk to the Dakota sandstone, which is usually so porous as to yield an excellent water supply. In the lower lands it lies at very moderate depths, but in the higher lands a deep boring is often required to reach it. On account of the definiteness of this water horizon it has been made the basis of water prediction in the Lancaster County area, as shown on Pl. XVII.

The waters of the Carboniferous limestone have been tested at Lincoln, and found to be highly saline. In a portion of this area the waters in the Dakota sandstone, also, are quite saline, owing, it is thought, to impregnation from springs or seepage from the underlying Carboniferous limestone. It is probable that these springs existed during the deposition of the Dakota formation, and have continued in greater or less volume since, for the present superficial deposits of the valley are highly impregnated with salt.

In the sand hills, especially those in northern Kearney and northeastern Phelps counties, more or less water is often found in the base of the sand accumulations, especially where the sand lies on a less permeable portion of the alluvial deposits. Quite a number of shallow wells in the sand-hill region find a satisfactory domestic supply of water without having to sink to the underlying alluvium or loess.

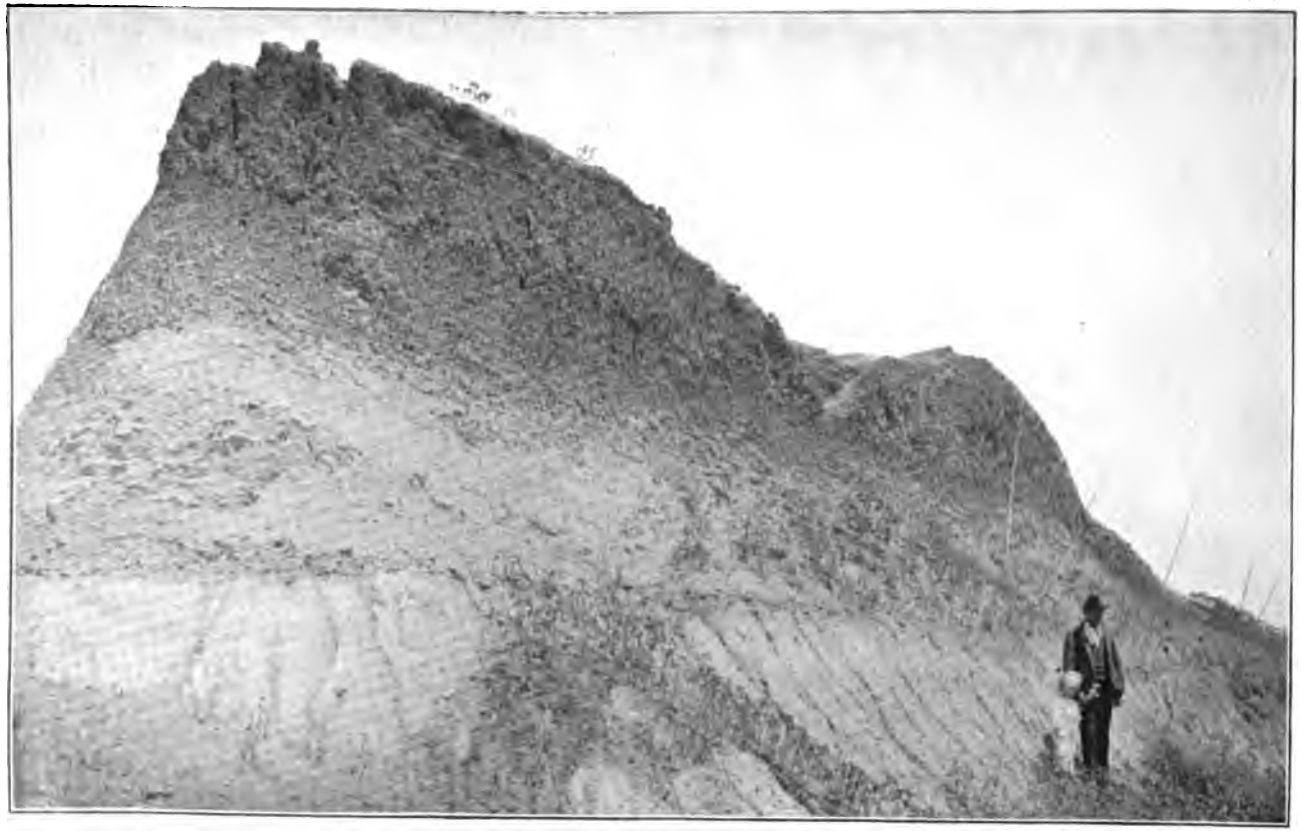
LANCASTER COUNTY.

Lancaster County lies within the area of glacial drift, which is underlain mainly by the Dakota sandstone. There are also wide valleys, mainly those of Salt Creek and its branches, filled with loess and alluvium. The principal water-bearing formation is the Dakota sandstone, but waters also occur among the drift deposits. The waters in the drift are of very irregular occurrence, but they furnish supplies for many scattered wells. As their distribution is governed by laws at present not well understood, it is almost impossible to make a general statement regarding them which would be of any value. In some cases, also, waters supposed to be derived from the drift may possibly accumulate through leakage from the underlying Dakota sandstone. This sandstone appears to carry water supplies throughout the area of Lancaster County, excepting about Roca and along the Little Nemaha River, where the limestones come to the surface, and at a few local points where the rock is less permeable than usual. The surface of the Dakota sandstone slopes, as a rule, gently eastward, although the general dip of the beds of the formation is toward the west. The contour of its surface under the heavy drift mantle is by no means regular, for it presents numerous ridges and mounds of various sizes, separated by irregular depressions, as shown in Pls. XX and XXI. The larger depressions of the county have been excavated through the drift, and in places more or less deeply into the Dakota formation, which gives further complexity to the contour of its surface.

As the Lancaster County region is one of high hills and ridges, the irregular surface of the Dakota sandstone lies at depths which vary greatly. These variations, however, are not too irregular for representation on a map, and in Pl. XVII there is shown the depth to the surface of the sandstone for each 50 feet from 50 to 250 feet. This representation is based on observations of the outcrops, which give a fairly good idea as to the surface configuration of the formation, and on the records of numerous wells which draw their waters from it. It will be seen that the depths are quite closely related to the altitude of the land above the principal valleys, and that there is also a somewhat general increase of depth to the north and northwest. In the area in which waters are shown to be obtainable at less than 50 feet below the surface the supplies are derived mainly from the Dakota sandstone, into which the depressions are excavated. In many portions of these depressions waters are available at considerably less than 50 feet below ground, but there is great irregularity in this regard.

The water supplies for the city of Lincoln are obtained from three pumping stations within the city limits. The Rice well, at Twenty-fourth and N streets, has a main well 50 feet deep and 40 feet in diameter. In its bottom there are seven wells 6 inches in diameter and 140 feet deep, from which the water flows up into the large well to within 15 feet of the ground when the pumps are not in operation. The water is almost perfectly fresh. The supply is augmented by six 6-inch gang wells, 140 feet deep, situated 150 feet south of the main well. The total product is stated to be 200,000 gallons a day. At the Park well, on F street near Sixth, there is a 50-foot well 75 feet in diameter. It contains three 6-inch tubular wells 40 feet deep. The water, which is somewhat salty, rises to within 10 feet of the ground, and the supply is 200,000 gallons a day. At South and Seventh streets there is a supplemental plant, from which the water is quite salty. It consists of a gang of 24 points, 55 to 58 feet deep, 4 inches in diameter, and yielding 150,000 to 200,000 gallons a day. The salinity of the waters used by the city of Lincoln from these three plants increases gradually from east to west toward the center of the salt-marsh area which lies along the western margin of the city. As the Dakota sandstone contains abundance of fresh water to the east and north of Lincoln it seems quite unnecessary that the city supplies should be in part drawn from the salt-basin area. Several deep borings made in Lincoln and vicinity obtained only salt waters. They passed through the Dakota sandstone, which furnishes the waters for the shallower wells, far into the Carboniferous limestones and underlying formations. The record of the well sunk by the State at the southern edge of the Salt Lake, now Burlington Beach, is given in fig. 7. This record was drawn mainly from the statements published by Mr. B. P. Russell,[1] the geologist who was placed in charge of the well.

[1] Sixth Biennial Report of the Commissioner of Public Lands and Buildings to the Governor of Nebraska, December 1, 1888, pp. 57-84.



GLACIAL DRIFT ON DAKOTA CLAY IN PITS SOUTHWEST OF INSANE ASYLUM NEAR LINCOLN, NEBRASKA.

LOESS ON GLACIAL DRIFT AND DAKOTA CLAY IN CLAY PITS SOUTHWEST OF INSANE ASYLUM NEAR LINCOLN, NEBRASKA.

Loess extends to level of tramway, which is on the thin layer of glacial gravel.

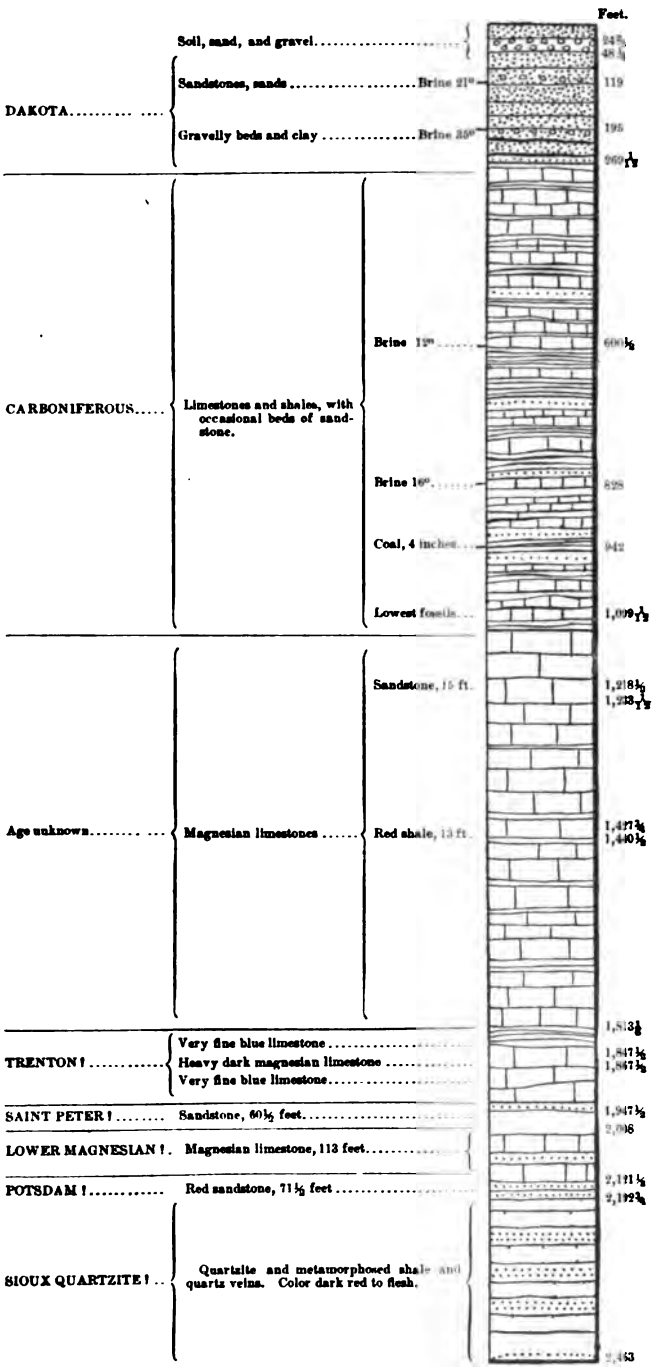


FIG. 7.—Section of salt well 1 mile west of Lincoln, Nebraska.

The borings were deposited in the museum at the State University, in Lincoln. So far as can be judged, the Dakota sandstone began at a depth of about 48 feet and extended to a depth of 269 feet 1 inch.

The clays at 208–214 feet, and the sandstone at 214–244 feet and 248–267 feet appear to be typical Dakota beds. The principal flow of water is from a reddish sandstone in the Carboniferous limestone at 600 feet. It is very saline. A similar flow is obtained at a depth of 570 feet at the sanitarium in Lincoln, and at 560 feet in the 1,050-foot well in the Post-office Square. In the State well another saline flow was found at 828 feet. The head of the water at the sanitarium is about 1,210 feet above sea level, its pressure being 15 pounds to the square inch.

SEWARD COUNTY.

The wells of Seward County draw their supplies from several sources. In the valley of West Blue River, in the vicinity of Beaver Crossing, there is a considerable area in which artesian flows are obtained. In the adjoining plains region the water is in gravels and sands underlying the loess. In the drift hills east of Blue River, waters are found in sands among the drift deposits and also in the underlying Dakota sandstone; and in the valleys of Big Blue River and some of its branches there are waters in the basal portions of the alluvial beds and in the underlying sands and gravels in which the valleys have been excavated. In most areas the supply of water found is very abundant, but at some points in the drift hills and about Seward the volume is small, so far as now developed.

The artesian area in West Blue Valley has been extensively explored by many wells. It begins about 6 miles below Beaver Crossing and extends to the western margin of the county on Beaver Creek and some distance into York County, up the South Branch Valley. Laterally the area of flow is limited by the lower slopes in the valley. About Beaver Crossing the head is sufficient to afford a flow to from 18 to 23 feet above the bottom lands. The head gradually diminishes up and down the valley as the ends of the artesian area are approached. The wells vary in depth from 90 to 140 feet, the shallower ones drawing from an upper stratum of water-bearing beds known as the "first flow." In Beaver Crossing the wells are mainly from 102 to 110 feet deep. The water is obtained from a bed of sand which lies under a sheet of clay extending from 40 to 90 feet. The wells in this artesian area are of various sizes, from 1 inch to 4 inches in diameter. The flows vary from 10 to 150 gallons a minute. The supposed geologic relations in this artesian area are shown in fig. 6, page 26.

It is said that flowing wells have been obtained at Ruby, and in one of the attempts to find deep-seated waters near Seward. The water at Seward was found at a depth of 336 feet, and, it is claimed, flowed out of a pipe 12 feet above ground, but only in small volume. This boring was four blocks east and four blocks south of the court-

RECENT VALLEY DEPOSITS ALONG SALT CREEK, IN EASTERN PORTION OF LANCASTER COUNTY, NEBRASKA.

house. In a boring reported to have attained a depth of 365 feet, a half-mile northeast of the court-house, a supply of water was found which is said to have come within 10 feet of the top (within 40 feet according to another authority). In another attempt to find deep water at Seward a boring was sunk to a depth of 610 feet, where it was abandoned in a mass of "red ocher" without obtaining a flow. From a partial record furnished of this boring the diagram, fig. 8, has been drawn. The red ocher reported in this boring is probably a highly ferruginous phase of the Dakota sandstone. If this is the case, it indicates that at Seward the upper portion of the Dakota formation is too fine grained to yield a water supply. It is unfortunate that the boring was not continued to lower beds of the formation, for, as they are usually coarser, they would no doubt have furnished a water supply.

FIG. 8.—Record of boring at Seward, Nebraska.

The principal wells about Seward have a depth of about 60 feet and obtain a fair supply of water in gravels and sands. At Tamora wells average 70 feet in depth and contain about 7 feet of water; at Utica the average depth of wells is 80 feet and the water rises from 1 foot to 2 feet in them. Similar conditions prevail over the greater part of the plains region in the central and western portions of Seward County. At Goehner wells are from 82 to 100 feet deep and contain 15 feet of water. At Cordova they are 105 feet deep and contain 10 feet of water. In the valley of Big Blue River, in the central and northern portion of the county, the water level is usually somewhat less than 50 feet below the ground; at Staplehurst it is 10 to 12 feet; at Bee wells average about 50 feet deep; at Germantown, far up among the drift hills, the wells are from 30 to 50 feet deep and contain from 10 to 15 feet of water.

Through much of the drift-covered country in the eastern portion of Seward County waters are obtainable within 50 feet of the surface in beds of sand and gravel in the drift. In some cases, however, the supplies are scanty and it is necessary to sink deeper wells. The experience with these deeper wells is exceedingly variable. A few in the vicinity of Pleasantdale have been sunk to the Dakota sandstone, which usually yields a satisfactory water supply at depths of 50 to 250 feet, depending upon the altitude of the land. One boring just south of the railroad, halfway between Pleasantdale and Milford,

penetrated the Dakota sandstone for 40 feet, but found it exceedingly hard and almost dry. This, however, appears to be a very exceptional condition.

NORTHERN SALINE COUNTY.

Only the northern half of this county was included in the area examined in 1896. It is a region in greater part of plains, traversed by the North Fork of Turkey Creek, and, near its eastern margin, by Big Blue River. East of the wide alluvium and loess plain in the valley of this river rise the slopes of the hills of glacial drift which are so prominent in the adjoining county of Lancaster. The underground waters which supply the plains region are found in a sheet of sand and gravel which underlies the loess. This water-bearing stratum lies between 60 and 90 feet below ground over the greater part of the plains portion of the county, and yields water to a large number of wells. At Friend the water level is 90 feet below ground. At Dorchester the town well is 110 feet deep, and the water rises to within 98 feet of the surface of the ground.

Along the valley of Turkey Creek and Big Blue River water supplies of greater or less amount are obtained at depths mainly of 30 to 40 feet. The shallower wells at Crete have a depth of about 40 feet, with a water surface 15 feet below ground. In deep wells, sunk for larger supplies for the city, a depth of 155 feet is attained, probably to the top of the Dakota sands. The wells contain 139 feet of water, the water level being 16 feet below ground. On the slopes of the drift hills east of Blue River the waters occur in a very irregular manner. Many of the wells are between 40 and 80 feet in depth, and obtain satisfactory water supplies. Other wells have been sunk to depths of from 120 to 180 feet, notably in an area at the head of Salt Creek, 4 miles southeast of Crete.

The Dakota sandstone underlies this county at no great depth, and might be expected to furnish water supplies, but few attempts have yet been made to reach the formation, as usually sufficient water for local use has been obtained in overlying deposits.

YORK COUNTY.

The greater part of York County is underlain by formations containing large supplies of water, which are in greater part available for wells less than 100 feet in depth. In two small districts on the higher plains the depths to the waters are slightly over 100 feet. These are south of McCool and on the north side of Lincoln Creek north of Bradshaw, where the wells are from 110 to 140 feet in depth, and contain from 10 to 30 feet of water, bringing the water level not much more than 100 feet below ground.

In the depressions of Blue River and its branches and of Beaver and Lincoln creeks it is only necessary to sink from 20 to 40 or 50 feet for abundant water supplies, which come from the same water-

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bearing beds as those which lie at greater depth beneath the higher lands. The greater number of wells in York have a depth of about 35 feet and contain 12 feet of water. In the higher land in the northern part of the town the waters lie about 30 feet deeper.

The following are a few representative wells of York County:

Wells in York County.

Locality.	Depth.	Depth of water in wells.
	Feet.	*Feet.*
McCool	15–25	2–5
Lushton	110	20
Charleston	80	----------
Henderson	94	7
Bradshaw	90–106	4
Benedict	100	15–20
Graham	----------	----------
Waco town wells	120	30
Waco	102	8–10

In the wide plain between McCool and York the water surface averages about 80 feet below ground, but it presents some slight variations. The greater number of the wells are from 80 to 100 feet deep. At Lushton another bed of water-bearing material also occurs, at a depth of 65 feet. On the plains between Beaver Creek and Turkey Creek the wells are 85 feet deep, and contain 15 feet of water. At Houston the water does not rise above the gravel in which it is contained.

North of Lincoln Creek the conditions are somewhat more variable, but the greater number of wells obtain abundant supplies of water, which rises to within 80 feet of the surface of the ground. In Arborville, which is on relatively low land, the town wells are 35 to 50 feet in depth, and the water rises to within 30 feet of the surface of the ground. In the adjacent higher lands the wells are from 50 to 100 feet in depth. At Waco the water rises 4 to 5 feet above the point where first reached.

The western extremity of the Beaver Crossing artesian area extends up the lowlands in the valley of South Branch of Blue River, in the extreme eastern part of this county. There are only a few flowing wells, but they obtain a fair supply of water from depths varying from 110 to 134 feet. Ascending the river, one finds the head gradually decreasing until no flow is obtainable; descending, an increased head is found, which at its greatest is sufficient to give a flow at 10 feet above the level of the bottom land.

Some years ago an attempt was made to obtain an artesian flow just south of York, at the Russian mill, where a depth of 590 feet

was attained. It is stated that a flow was found at a depth of 530 feet, which spouted 2 feet above the top of a tube extending 14 feet above ground; but this statement could not be authenticated satisfactorily. A small flow was reported at 290 (or 390?) feet. There also appears to be uncertainty in regard to the record of the boring, but according to the most consistent statement, there was fine-grained material to 93 feet, sand and gravel from 93 to 100 feet, shale from 199 feet for a considerable depth, and sandstone at the bottom, in which the drill stuck at a depth of 590 feet. The sandstone may possibly be the Dakota formation.

A deep boring was started at McCool, but it was abandoned at a depth of 150 feet. The following record was furnished by Mr. D. C. Kims, the borer:

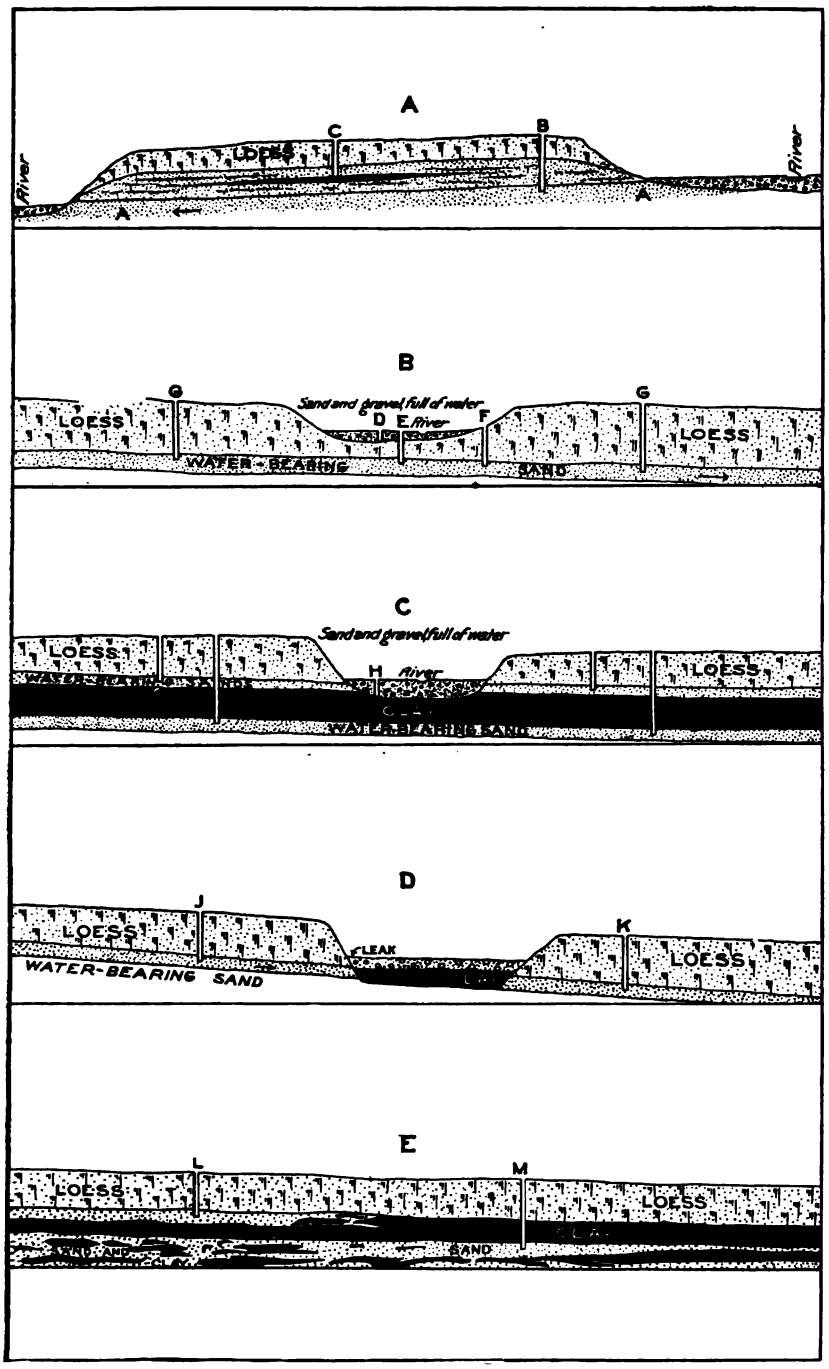
Feet.	
0– 30	Loam.
30	Water.
30– 70	Sand.
70–100	Yellow clay.
100–107	Soft white rock.
107–118	Blue sand and water.
118–150	Tough blue clay, with a 2-foot rock layer.

FILLMORE COUNTY.

In this county the conditions are very similar to those of York County. There are fewer deep valleys, and over the wide, level plains area the wells find abundant water supplies, which usually rise to within from 60 to 90 feet of the surface of the ground. Some of the wells have gone deeper to secure larger volumes of water, but the level to which the water rises is nearly constant over the area. Some representative wells are as follows:

Wells in Fillmore County.

Locality.	Depth.	Depth of water in wells.
	Feet.	*Feet.*
Fairmont	30–70	15–20
Railroad station	237	157
Geneva	120	35
Sawyer	65–75	12–20
Sutton, city supply	140	60
Saronville, town wells	80	15
Strang	80–100	15–30
Exeter	40	15
Martland	96	5
Shickley	85–100	5–10



SECTIONS ILLUSTRATING SOME SPECIAL CONDITIONS AFFECTING UNDERGROUND WATERS IN SOUTH-CENTRAL NEBRASKA.

A record of the well at the railroad station at Fairmont is given in fig. 9.

Some tubular wells in the neighborhood of Saronville are from 140 to 150 feet deep, with large volume of water. At Exeter the water-bearing beds are exceptionally near the surface of the ground.

HAMILTON COUNTY.

This county comprises a wide area of plains, its northwest corner extending, however, part way across Platte Valley. It is underlain by a sheet of water-bearing gravels and sands that are exposed in the deep valleys of several branches of Blue River which traverse the central and eastern portions of the county. On the plains surface lying between these valleys the water-bearing stratum is covered with loess to depths of from 50 to 80 feet. In the valley of Platte River the principal water supplies are in the alluvial gravels and sands at depths less than 25 feet.

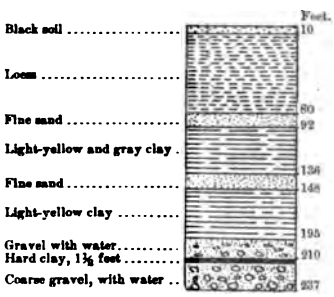


FIG. 9.—Record of deep well at Fairmont, Nebraska.

In the greater part of the plains area the water-bearing beds lie from 60 to 90 feet below ground. In a few small areas about Aurora and northwestward the water level lies deeper than 100 feet, but, so far as ascertained, good supplies are always obtainable within 125 feet of the surface, the water usually rising to within 100 to 110 feet of the surface of the ground. At Aurora the principal wells have a depth of 110 to 125 feet, with the water level 100 feet below ground. About Bromfield (Giltner post-office) the wells average from 75 to 95 feet in depth and generally contain from 6 to 15 feet of water. About Phillips the water level averages about 90 feet below ground. At Marquette the wells vary in depth from 100 to 130 feet. The town well is 130 feet deep, and the water rises to within 97 feet of the surface of the ground. In another well, 105 feet deep, the water level stands within 99 feet of the surface. At Hampton wells average from 85 to 105 feet in depth, with the water level at about 80 feet below ground. In the valley of Platte River the water level lies from 5 to 8 feet below ground in the vicinity of the river and for a mile and a half westward, beyond which for a wide area the water level seldom exceeds a depth of 15 or 20 feet below ground. In the depressions along the branches of Blue River which traverse the central and eastern portions of this county there are usually excellent water supplies to be had within 30 or 40 feet of the surface, and there is considerable running water in the stream, derived partly from the outcrops of water-bearing beds which furnish supplies of water for the moderately deep wells on the higher lands.

CLAY COUNTY.

This county lies altogether on the high plains, and wide areas of its surface have only a gentle, uniform slope toward the east. In the northern portion of the county there are broad troughs cut by branches of the South Branch of Blue River, and the southwestern corner of the county is crossed by the valley of Little Blue River. The relations of the underground waters are very simple, the water-bearing stratum consisting of gravels and sand lying beneath the loess and dipping gently eastward at a rate very little less than the slope of the plains surface. The water level is about 60 or 70 feet below ground over wide areas, and it is rarely necessary to sink a well to a depth of more than 120 feet to obtain an abundant supply. A large number of wells have a depth slightly less than 100 feet and contain from 10 to 15 feet of water. In the vicinity of Inland and Trumbull there are a few wells in which the waters lie a little deeper than 100 feet.

In the depressions of Little Blue and the branches of Big Blue rivers, waters are obtainable at depths of 20 to 40 feet in greater part. At Fairfield the wells vary from 80 to 100 feet in depth and contain large supplies of water, which rises about 10 feet above the bottom.

At Harvard the wells are generally slightly less than 100 feet deep, but a few have gone somewhat deeper to obtain larger volumes of water. At Clay Center the wells average 100 feet in depth, with the water level at about 85 feet below ground; at Inland, 120 feet, with the water level 110 feet; at Trumbull, 115 to 120 feet, with the water level 110 feet; at Glenville, 103 feet, with the water level 97 feet; at Saronville, 80 feet, with the water level 65 feet; at Sutton, 140 feet, with the water level 80 feet. At Deweese the wells average from 40 to 50 feet in depth and contain from 10 to 15 feet of water. At Edgar the wells are 88 feet deep, with 8 feet of water. At Ong the wells average 80 feet deep, with from 1 to 3 feet of water.

HALL COUNTY.

The greater part of this county lies in the valley of Platte River. In its southwestern corner there is a level area of plains country 60 to 80 feet higher, and in the northwestern corner an area of plains ridges and sand dunes, with the valley of the South Fork of Loup River beyond.

In the wide valley of Platte River the relations of the underground waters are very uniform. The supplies are large and the depth to the water surface is very slight. In the immediate vicinity of the river there is a narrow belt of country in which the water level is less than 10 feet below ground. About Grand Island and westward it lies from 15 to 20 feet deep in greater part, but in some of the lower areas it is nearer the surface of the ground. In the plains region about Doniphan and southwestward the waters lie between 60 and 100 feet

SPRING FROM DAKOTA SANDSTONE ALONG MISSOURI RIVER NEAR MOUTH OF PLATTE RIVER, SARPY COUNTY, NEBRASKA.

below ground, the depth increasing somewhat in the higher land west of Hansen. The tubular wells in this vicinity are usually sunk to a depth of 130 feet, but have the same water level as the shallower borings. In the higher ridges southwest of Cairo the wells ordinarily obtain satisfactory water supplies, but have to be sunk to a depth of 120 to 140 feet. At the waterworks in Grand Island there are thirty-six 2-inch driven wells, 54 feet deep, in which water rises to within 16 feet of the surface of the ground. There are pumped from these wells 1,000,000 gallons per day. Moderate supplies of water are found within 20 feet of the surface, but it was necessary to go considerably deeper to obtain the town supply.

About Abbott the wells are from 25 to 40 feet deep, with the water level at about 18 feet below ground. At Cairo the wells on the higher land are 60 feet deep and contain 35 feet of water.

In the Loup Valley the conditions are similar to those in the Platte Valley eastward.

ADAMS COUNTY.

The underflow from Platte River passes southeastward under Adams County through sands and gravels which present everywhere relatively uniform relations. The waters are more or less free to escape into the valley of Little Blue River, which quite deeply trenches the plains region in the southern portion of this county. The depth to the waters varies closely in relation to the altitude of the land, making due allowance, however, for the uniform slope of both the land and the water-bearing beds to the east and southeast.

In the higher portion of the plains separating the valley of Platte River from that of Little Blue River the water level lies between 100 and 125 feet beneath the surface over considerable areas, as shown in Pl. XVII. On the less elevated areas adjacent, the depths are considerably less—usually from 60 to 80 feet; while in the valley of Platte River, in the extreme northwestern corner of the county, and in the depressions of Little Blue River and its branches to the south, the waters are very near the surface of the ground. At Hastings a large supply of water for city use is obtained from seven wells sunk to a depth averaging 140 feet and containing about 20 feet of water. An attempt was made to obtain water from a deeper source (300 feet), but the 120-foot horizon was found to be the most serviceable.

Some years ago a deep boring was made at Hastings for oil or gas, which has thrown some light on the deeper underground geology of the region. A record published by W. W. Follett[1] is here reproduced in graphic form in fig. 10 (p. 38).

From another authority it was learned that the total depth was 1,346½ feet, the lower 370 feet being reported as "soft shale limestone,

[1] Report on Irrigation, 52d Cong., 1st sess., Senate, Ex. Doc. 41, Part II, Washington, 1893, Pl. XXV.

sand, and gravel, with seashells at 1,300 feet." Hard limestone 1½ feet thick was reported at 775 to 776 feet, soft limestone and shale from 776 to 801½ feet, and light shale and lime rock from 930½ to 976½ feet. The shale was stated to be hard from 250 to 500 feet and soft from 500 to 775 feet.

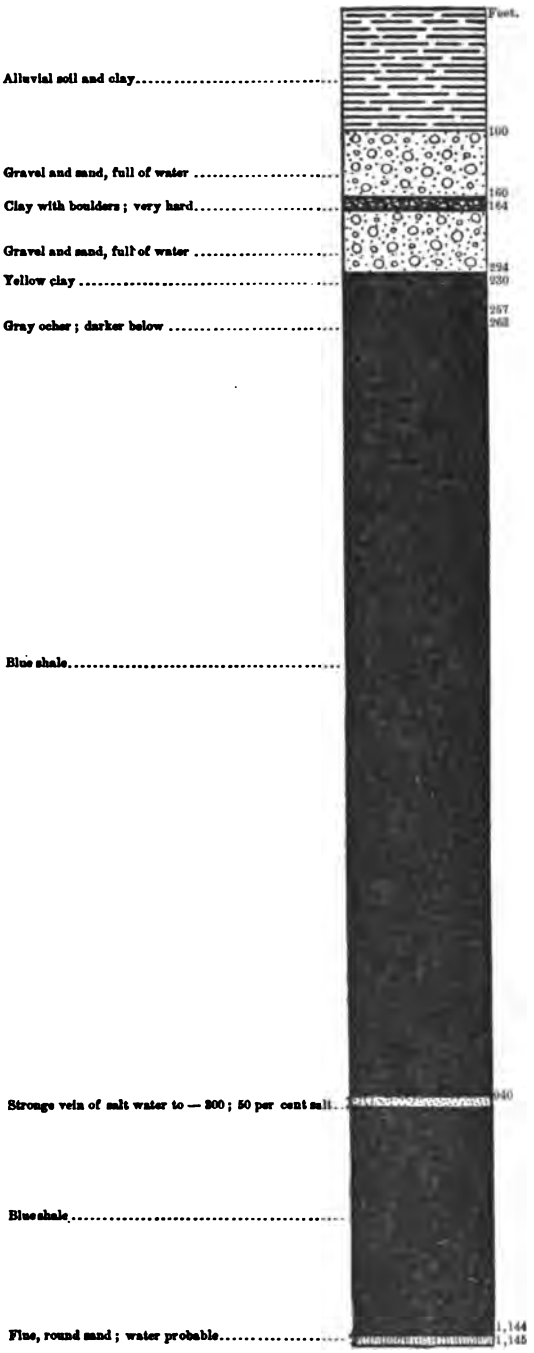
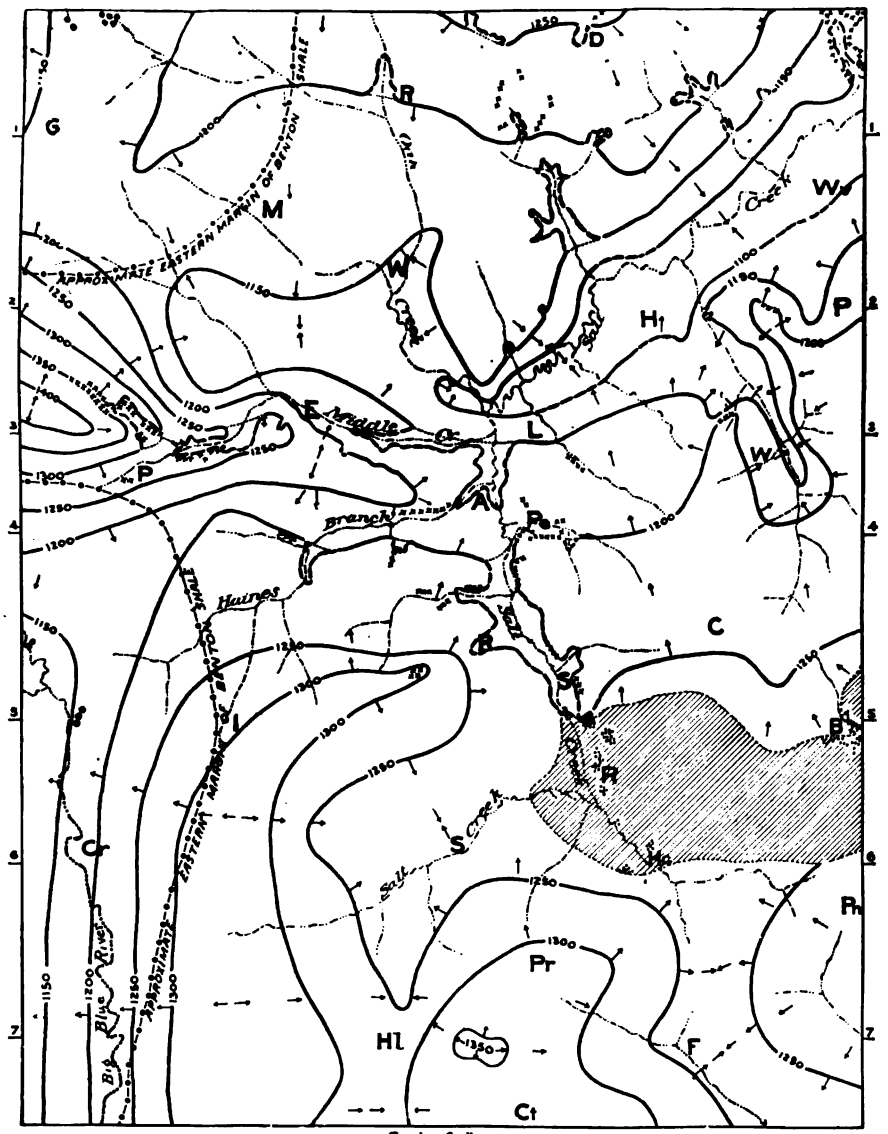


FIG. 10.—Record of deep boring at Hastings, Nebraska.

At Juniata wells are of somewhat variable depth, but they average slightly less than 100 feet and contain about 10 feet of water. At Kenesaw, wells from 90 to 115 feet deep have their water level at about 80 feet below ground. At Prosser the town well has a depth of 115 feet, with the water level 112 feet below ground, slightly deeper than in the adjoining region to the north. At Hansen the water level lies about 70 feet deep. At Roseland the wells average from 80 to 105 feet in depth, with the water level about 80 feet below ground. At Holstein the wells are 130 feet deep, and contain 25 feet of water. At Pauline wells vary from 85 to 105 feet, with the water level at from 80 to 90 feet, depending upon the proximity to Little Blue River. At Ayr a fairly satisfactory supply of water is found at a depth of 30 feet, which rises but little above the bottom of the boring, and the supply varies with the weather.



MAP SHOWING CONTOUR AND RELATIONS OF SURFACE OF DAKOTA SANDSTONE IN THE VICINITY OF LINCOLN, NEBRASKA.

The heavy black lines indicate altitudes above sea level of the surface of the Dakota sandstone. The broken lines indicate depressions cut in this surface since the Glacial period the dotted lines showing the original configuration. The arrows point to the direction of slope. Present drainage shown by broken-and-dotted lines

L	Lincoln.	W.	Woodlawn.	B.	Bennett	Hc.	Hickman.
E.	Emerald.	xxP	Pleasantdale.	Pn	Panama.	A.	Asylum.
Sx.	Saltillo	Cr.	Crete.	G.	Germantown	Pe	Penitentiary.
Wv.	Waverly.	M	Malcomb	Hl.	Hallam	H.	Havelock.
Pr.	Princeton.	D.	Davey.	R.	Rokeby	P.	Prairie Home.
Ct	Cortland.	R.	Raymond.	S.	Sprague.	W.	Walton.
F.	Firth.	C	Cheney				

BUFFALO COUNTY.

Buffalo County comprises portions of the Platte and Wood River and South Fork of Loup River valleys, with wide areas of intervening high plains. The depths of the underground waters are closely related to the altitude of the land above Platte River, the water-bearing strata sloping eastward at about the same degree of inclination as the slope of the general surface. As the valley of South Fork of Loup River is somewhat lower than the bed of Platte River, and there are beds of permeable material extending under the high plains from one to the other, there is a sheet of water under Buffalo County which is probably moving toward the northeast. This sheet of water furnishes a large volume to many wells in all parts of the county. Immediately along Platte River the wells are very shallow, the water rising to within from 5 to 9 feet of the surface of the ground. This area of shallow wells widens considerably in the vicinity of Gibbon, and extends for some miles, nearly to the Union Pacific Railroad. At Gibbon the water level is within 10 feet of the surface and furnishes large supplies to wells from 25 to 35 feet in depth.

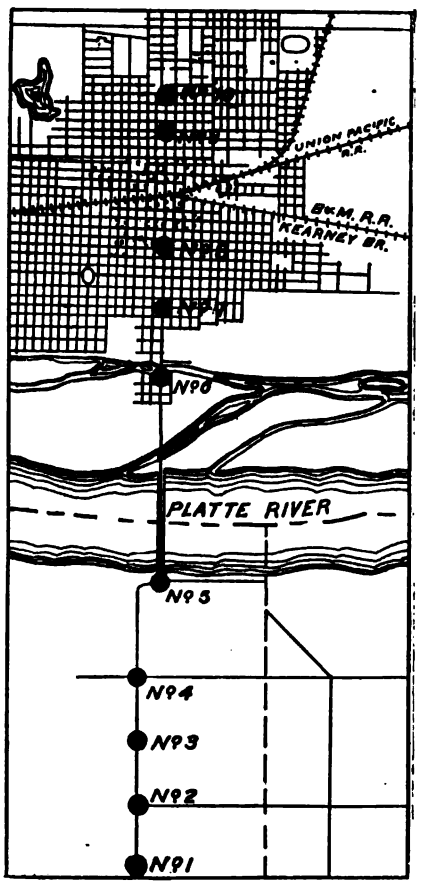


FIG. 11.—Map showing location of gage wells at Kearney, Nebraska.

Next north of this zone and occupying the remainder of the wide valley of Platte River, with an extension up the valley of Wood River, there is a wide area in which the water surface lies between 15 and 40 feet below ground, and similar conditions exist along the valley of the South Fork of Loup River. At Kearney the principal supplies of water are obtained 20 feet below ground in wells from 25 to 35 feet deep in greater part, the depth increasing somewhat and the altitude of the water surface decreasing notably from south to north across the city.

At Odessa wells are 20 feet deep; at Elm Creek 14 feet. At Riverdale, in Wood River Valley, wells 102 feet deep contain 77 feet of water, but other shallower wells in the vicinity have water at the

same level. At Amherst the water level is 25 feet below ground. At Watertown the wells are 85 feet deep. At Miller the town wells are 73½ feet deep and contain 40 feet of water. At Sartoria wells are 22 feet deep and contain 12 feet of water. At Pleasanton they are 15 feet deep. At Ravenna it is found necessary to go to a depth of 60 feet for a good flow, but the water rises to within 20 feet of the surface. Surface waters of relatively poor quality are found at a depth of 30 feet, which rise to the same level.

Over the greater part of the ridge south of the South Fork of the Loup River the water surface is generally from 100 to 150 feet below ground toward the valleys. Along the central ridge north of Amherst is a tract in which it is found necessary to go somewhat deeper, the wells having a depth of 170 to 250 feet, with the water level about 150 feet below ground. In the ridge extending northwest of Kearney between the Platte Valley and the valley of Wood River the conditions are similar to those in the land north of Wood River, and they are the same along the northern edge of the county, north of the South Fork of Loup River.

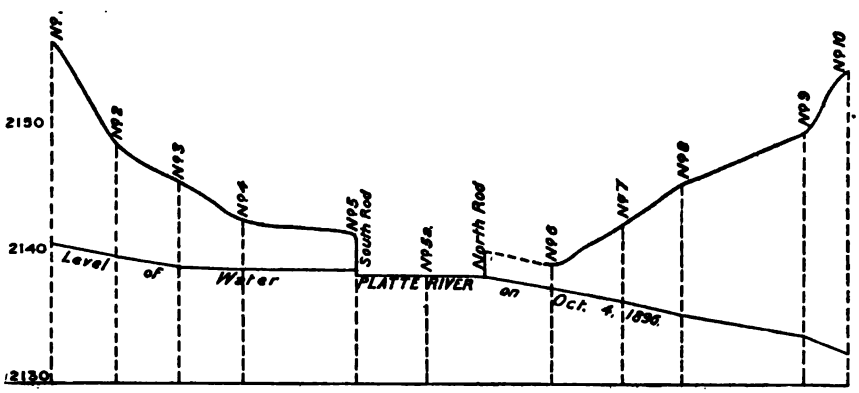
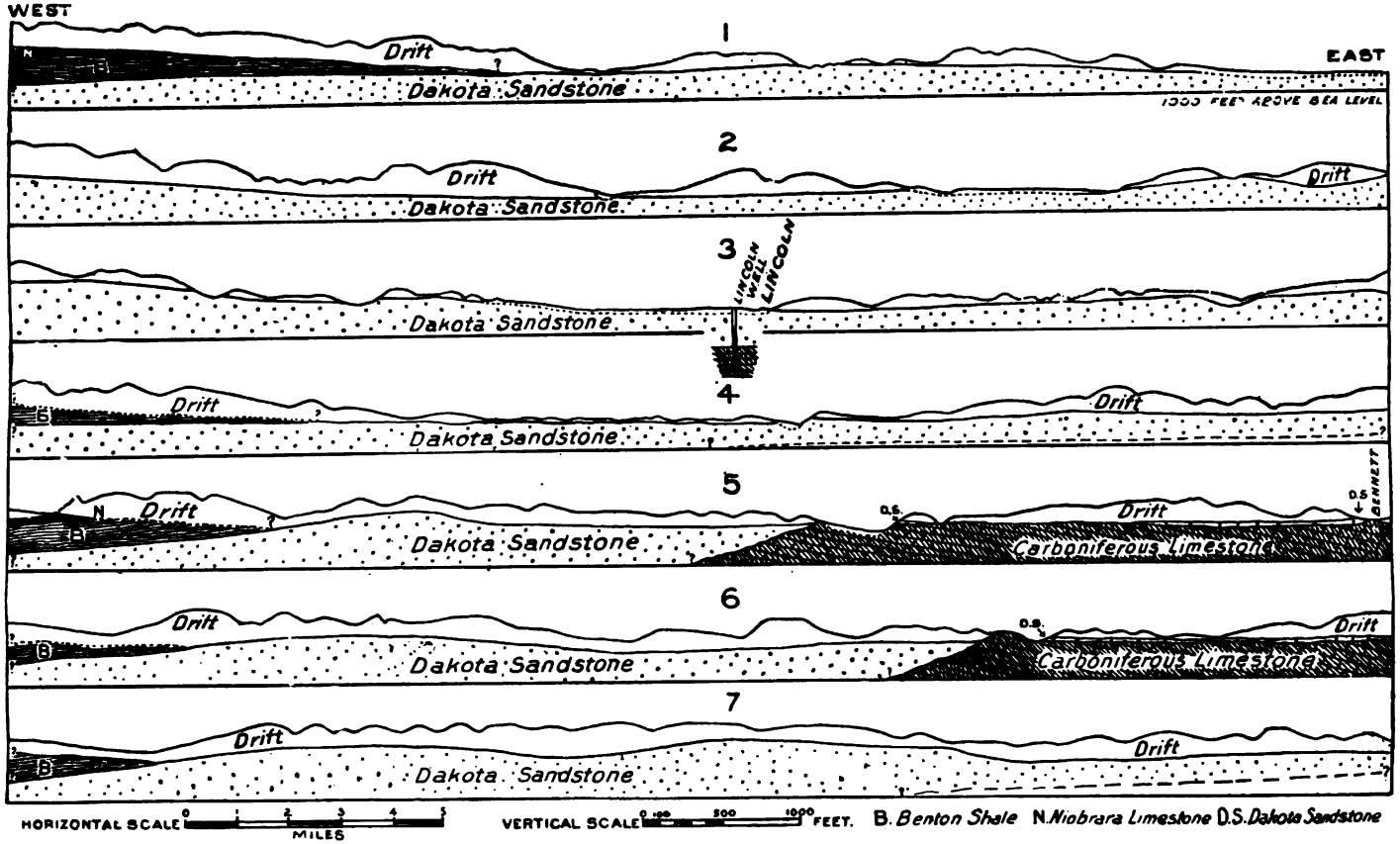


FIG. 12.—Profile of line of wells along Central avenue, Kearney, Nebraska.

GAGE WELLS AT KEARNEY.

A series of wells were sunk under the direction of Prof. O. V. P. Stout during the spring of 1896. These were located in a nearly north-south line, at distances of about one-half mile from each other. The first, or No. 1, is in the sand hills 2½ miles south of the bridge across Platte River at Kearney, on the main road. Nos. 2, 3, and 4 are successively one-half mile apart north from No. 1. No. 5 is on the south bank of the river. There is also near this a gage rod, marked in the table "S. R.," this being the southerly gage, showing the height of open water. About the middle of the bridge is a well, known as "5*a*," sunk in the low island, submerged at high water. At the north end of the bridge is the gage rod marked in the table "N. R.," about one-half mile from well No. 6, on the north side of the river. This well was tampered with and subsequently replaced, readings being begun on August 17. The remaining wells, Nos. 7, 8, 9, and 10, are



CROSS SECTIONS SHOWING RELATIONS OF DAKOTA SANDSTONE IN THE VICINITY OF LINCOLN NEBRASKA.

on Central avenue in Kearney, Nos. 9 and 10 being a short distance north of Midway Hotel. The elevations of the tops of the well casings, as determined by careful leveling, and of the zeros of the two rods, are given in the following list, referred to the Union Pacific datum:

Elevation of top of well casing; wells near Kearney.

Well.	Elevation.	Well.	Elevation.
	Feet.		*Feet.*
No. 1	2,157	No. N. R	2,137.49
No. 2	2,148.96	No. 6	2,139.50
No. 3	2,145.97	No. 7	2,142.66
No. 4	2,143.01	No. 8	2,146.31
No. 5	2,141.88	No. 9	2,149.82
No. S. R	2,137.57	No. 10	2,154.85
No. 5*a*	2,139.99		

The following table gives the reading of distance of the water surface below the top of the well casing:

Distance of water surface below top of well casing; wells near Kearney.

Date.	Day.	1.	2.	3.	4.	5.	S. R.	5*a*.	N. R.	6.	7.	8.	9.	10.
April	19	.....	9.90	7.00	3.30	2.90	.....	.....	.....	1.30	6.70	11.50	17.70	23.10
	26	.....	9.70	6.40	3.80	3.00	.....	.....	.....	.....	6.20	11.00	17.10	22.70
May	3	.....	9.10	6.10	3.10	2.90	.....	.....	.....	.....	6.50	11.40	17.60	23.10
	10	.....	9.40	6.85	3.40	3.00	.....	.....	.....	.....	6.20	11.15	17.35	22.90
	18	.....	9.26	6.45	3.10	2.85	.....	.....	.....	.....	6.55	11.80	17.10	23.50
	25	16.50	9.45	6.62	3.38	3.05	.....	.....	.....	.....	6.80	11.37	17.36	23.65
June	1	16.04	9.05	6.55	2.93	2.82	.....	.....	.....	.....	5.90	10.92	16.95	23.15
	8	16.25	9.28	6.62	3.10	3.02	.....	.....	.....	.....	6.01	11.10	17.10	23.28
	18	16.50	9.56	6.83	3.35	3.40	.....	.....	.....	.....	5.81	10.75	16.98	22.95
	23	16.55	9.60	6.90	3.45	3.50	.....	.....	.....	.....	5.89	10.80	17.10	23.20
	30	16.43	9.61	6.70	3.15	3.12	.....	.....	.....	.....	5.68	10.61	16.76	22.65
July	9	16.40	9.38	6.61	3.18	3.15	.....	.....	.....	.....	5.59	10.35	16.68	22.83
	16	16.80	9.85	7.10	3.61	3.72	.....	.....	.....	.....	6.01	10.98	17.30	23.31
Aug	12	15.39	8.65	6.36	4.09	2.76	1.11	.....	1.20	.....	6.08	10.56	16.05	22.06
	17	15.50	8.78	6.42	4.00	2.81	0.98	1.94	1.26	1.94	6.25	10.59	16.05	22.14
	22	15.43	8.75	5.81	4.02	2.92	0.89	1.70	1.09	2.15	6.11	10.94	16.08	22.13
	29	15.69	8.84	6.53	4.16	3.95	—0.52	2.49	—0.43	2.61	6.25	10.63	16.16	22.15
Sept	5	15.71	8.85	6.56	4.20	3.87	—0.17	2.52	—0.23	2.69	6.30	10.67	16.13	22.12
	12	15.75	8.89	6.60	4.24	3.96	0.84	1.57	—0.07	2.63	6.41	10.73	16.15	22.14
	19	15.80	8.94	6.65	4.18	2.75	1.07	1.39	1.23	1.95	6.27	10.76	16.21	22.22
	28	15.84	8.97	6.68	4.07	2.81	1.03	1.35	1.18	1.96	6.16	10.80	16.25	22.25
Oct	4	15.88	9.01	6.72	4.05	2.84	0.95	1.40	1.16	1.99	6.12	10.75	16.25	22.25
	11	15.91	9.05	6.76	4.05	2.81	1.01	1.49	0.79	2.13	6.15	10.79	16.29	22.29
	18	15.92	9.06	6.77	3.97	2.78	1.03	1.42	1.06	1.89	6.04	.....	16.30	22.30
	26	15.95	9.11	6.70	3.94	2.80	1.08	1.42	0.98	1.75	6.06	.....	16.33	22.33
	31	15.97	9.13	6.79	3.90	2.65	1.15	1.10	1.34	1.39	6.06	.....	16.30	22.30
Nov	8	16.00	9.18	6.74	3.82	2.54	1.82	.....	1.94	1.28	6.08	.....	16.36	22.32
	15	16.02	9.20	6.69	3.76	2.71	1.13	1.25	1.38	1.95	6.11	.....	16.38	22.36
	21	16.05	9.22	6.73	3.76	2.55	.....	.....	.....	2.04	6.08	10.85	16.41	22.39
	30	16.08	9.24	6.76	3.72	2.39	1.39	Frozen	1.58	1.82	6.13	10.76	16.45	22.47
Dec	7	16.11	9.27	6.65	3.65	2.50	1.35	.....	0.86	1.87	6.15	10.98	16.40	22.40
	13	16.13	9.29	6.57	3.59	2.52	1.29	0.98	1.45	1.55	6.06	10.80	16.42	22.39
	19	16.16	9.33	6.52	3.54	2.46	1.52	Frozen	1.51	1.75	6.00	10.82	16.45	22.40
	29	16.14	9.25	6.54	3.55	2.45	1.36	Frozen	1.53	2.00	5.98	10.77	16.41	22.43

KEARNEY COUNTY.

Kearney County extends from Platte River far southward across the divide between the Platte and Republican rivers. The greater part of its area is high, level plains, terminated northward by the Platte Valley along a zone bordered by sand hills. Little Blue River heads in the eastern part of the county and has cut a moderately deep valley north of Norman. The underground waters lie in a sheet of gravels and sand which slopes gently to the east and southeast. Under the higher land in the central and southwestern portion of the county they lie from 100 to 155 feet below ground. To the north and east the depth diminishes gradually, and in the lower lands along Platte Valley they are only a few feet below ground. At Minden the water level is 80 feet below ground, but ordinarily wells are sunk 40 or 50 feet into the water-bearing beds.

As the land rises to the southeast the underground waters lie deeper, but as the water-bearing horizon also rises gradually to the west the increase in depth does not correspond precisely with the increased altitude of the land. At Keene the water level is about 105 feet below ground, and wells are sunk to a depth of 120 to 160 feet. North of Wilcox the water level varies from 110 to 135 feet in a rather irregular manner; and to the south, as the land rises rapidly in the southwestern corner of the county, the water level is found to be considerably over 150 feet below ground. At Axtel the water level closely approximates 100 feet below ground, being a little less to the north and a little more to the south. At Norman the town wells have a depth of 100 to 125 feet, with the water level at about 95 feet below ground. About Hartwell the water level is about 65 feet deep, but is somewhat deeper than this in the village. Along the belt of sand hills the waters are obtained at various depths, but often fair supplies are yielded by moderately shallow wells. On the lower lands in the Platte Valley the waters are rarely over 45 feet below ground, the depth gradually decreasing toward the river. About Lowell the water surface is from 6 to 9 feet below ground; at Newark it averages about 8 feet, but wells ordinarily are sunk 8 or 10 feet into the water-bearing beds.

PHELPS COUNTY.

The configuration and relations in Phelps County are similar to those of Kearney County, but the flat-topped divide between the Platte and Republican valleys is a somewhat more elevated ridge. Along the southern margin of the county the land slopes toward Republican River, and in the southwestern corner of the county, which was not investigated as to its water resources, there are deep canyons which contain head waters of small lateral branches of

Republican River. The underground waters lie in a sheet of gravel and sand, which dips southeastward, but presents some local variations in the regularity of its inclination. The dip of the beds to the southeast is slightly less than the upward slope of the land southwestward, so that to the north and east the waters lie at a less depth than they do farther west. In the highest area of the plains, southwest of Holdrege, the water level lies over 200 feet below ground. The depth decreases regularly northeastward to the edge of the plains south of the valley of Platte River. In the valley of Platte River there is a narrow strip of land along the river in which the water level is less than 10 feet below ground, but southward, through the belt of sand hills to the edge of the valley, the waters lie mainly within 25 feet of the surface of the ground.

At Holdrege the city wells have a depth of 200 feet and contain 60 feet of water. The water level in the vicinity is very uniformly at 140 to 160 feet below ground. At Atlanta it is 180 feet below ground; about Sacramento it varies from 120 to 140 feet; at Funk it is 125 feet; at Axtel, 100 feet; and at Loomis, 180 to 190 feet.

DAWSON COUNTY.

The underground waters of Dawson County present a wide range of variation in their depths, from very near the surface in the immediate vicinity of Platte River to over 300 feet in the high lands in the northwestern portion of the county.

The water level corresponds quite closely in altitude with the bed of Platte River and has a similar gentle inclination to the east and southeast. The exceptional depth of the waters in the northern portion of the county is therefore mainly due to the altitude of the land above the river, but it is in some measure increased by a diminished quantity of water in the upper beds of the water-bearing series. The zone in which the water surface is less than 10 feet below ground is narrow along the south side of Platte River, but extends to and beyond the Union Pacific Railroad at some points east of Lexington, and it is unusually wide in the vicinity of Cozad. In Cozad an excellent supply of water is obtainable at depths of 6 to 8 feet below ground in wells from 20 to 30 feet deep. About Lexington the water surface is from 21 to 22 feet below ground, and wells average from 25 to 35 feet in depth. Similar conditions prevail over a wide belt extending northward to the base of the slopes which rise to the table-land lying between the valleys of Platte and the South Fork of Loup rivers, the depths gradually increasing as the land gains in latitude.

North from Cozad, where the bottom of the valley has a relatively rapid rise, there is a considerable area within the valley where the water surface is over 50 feet below ground and wells are between 100 and 120 feet deep. In the high ground lying between the valleys

of Platte and Wood rivers, and again on the north side of the valley of Wood River, the waters lie at a depth below ground in proportion to the increasing height of the land. Eastward in this region there are wells which obtain water supplies within 200 feet of the surface of the ground, but westward the water surface rises less rapidly than the land surface, and it is necessary to go considerably deeper for water supplies. In this portion of the county the greater number of wells are sunk in depressions, to avoid the necessity for sinking them to the depth necessary on the higher ridges. Wells on the higher lands are over 300 feet deep.

In the valley of Wood River the water surface lies from 25 to 35 feet below ground in greater part, and yields satisfactory supplies to many wells of moderate depth. At Sumner the principal supplies are obtained from wells 93 feet deep, in which the water surface is 25 feet below ground.

In the south-central portion of Dawson County there are abundant water supplies at moderate depth in the valley of Platte River, obtained in wells from 25 to 30 feet deep near the river and from 35 to 45 feet deep back toward the foot of the upland. Southward, on the top of the table-land, the water surface lies from 220 to 250 feet below ground in greater part, but there are a few local exceptions. The wells are mainly tubular and have depths of 222 to 285 feet.

NORTHERN GOSPER COUNTY.

The greater part of this region is an elevated plain, invaded from the south by many canyons at the heads of branches of the Republican River, and traversed northward by the wide, deep valley of Plum Creek. Its northeastern corner extends to Platte River and covers a small area along the south side of the valley of Platte River. The underground waters lie at approximately the same altitude as the bed of Platte River, with a gentle general slope to the east and southeast. The waters are in a great sheet which is probably flowing very slowly to the east, and in some measure to the south into the deep valley of Republican River. The depth to the water surface is closely related to the altitude of the land above Platte River.

Along the central area of plains constituting the divide between Plum Creek and waters draining into the Republican River the water surface lies from 180 to 280 feet below ground, the increase being quite regular to the west. About Smithfield wells have a depth of 240 feet and contain 18 feet of water; at Elwood the depth is 320 feet and the wells contain 20 feet of water. On the high lands between Plum Creek and the Platte Valley the water surface lies 150 feet below ground north of Smithfield, and between 200 and 220 feet north of Elwood and in the extreme northwestern corner of the county. Along Plum Creek, waters are usually obtained within 150 feet of the surface in the western part of the county, and within 50 feet of the surface in

the eastern part of the county, the rate of decrease being fairly regular as the valley is descended. In the valley of Platte River, in the northeastern corner of the county, the water surface lies within 6 feet of the ground surface immediately adjoining the river, and within from 20 to 30 feet toward the foot of the highlands.

PROSPECTS FOR DEEPER-SEATED WATERS.

Although a number of deep borings have been made in the central and western portions of the area to which this report pertains, they appear not to have gone to a depth sufficient to reach the formations in which water supplies might be expected. A boring at Kearney attained a depth stated to be 2,460 feet, where it was discontinued, far down in the Pierre shale. One at Hastings reached a depth of 1,145 feet; one at Dannebrog a depth of 1,000 feet; one at York, 590 feet; and one at Seward was bored to a depth of 610 feet. At the latter place the Dakota sandstone appears to have been penetrated, but it did not yield a flow. In the other borings this formation was not reached.

In South Dakota the Dakota sandstone carries a very large volume of excellent water under high pressure which is available over a wide area in the eastern part of the State and in the depressions of the Missouri and confluent valleys. This water passes into the formations along the foothills of the Black Hills and the Rocky Mountains at altitudes of from 3,000 to 5,000 feet, and has a great pressure and high head in the eastern part of South Dakota. This pressure and head diminishes gradually toward the southeast, and finally in the extreme corner of the State flowing water can not be obtained. This is due to the fact that the formation reaches the surface along Big Sioux River and the Missouri River below Vermilion, so that the waters are free to escape and thus lose their volume and pressure. Precisely the same conditions are found in the northeastern corner of Nebraska, and it is reasonable to believe that they may be found to be essentially the same over a wide area in central Nebraska, especially on the lower plains and along such valleys as the Platte, where the land is not elevated much higher than in the eastern part of South Dakota.

The Dakota sandstones outcrop in Lancaster and adjoining counties, where they are free to lose their water, and this is also the case with the upper members of the Carboniferous formations which outcrop extensively in the counties east and southeast of Lancaster. In this area the Dakota sandstone is seen to be full of water in hundreds of wells which have been sunk in it, and from its outcrops flow innumerable springs, which do much toward filling the small streams of Lancaster County. These waters are in all probability largely derived from an intake zone along the western outcrops, and it is believed that much of the water passes under the entire length of the State of Nebraska, as shown in Pl. IV, to the wells and springs which

extend along a zone of outcrop of Dakota sandstone in Lancaster, Gage, Saunders, Dodge, Burt, Thurston, and Dakota counties. A typical spring in this belt is shown in Pl. XIX. Of course these waters have but very slight head in Lancaster County, but they nearly all rise at least a few feet in the wells which are sunk to them. Westward, however, away from the zone of leakage, we should expect the pressure to gradually increase, as it does to the north and west in South Dakota. Whether the increase would be at a sufficiently rapid rate to give flows at the surface in the central and western portion of the area to which this report relates can not be predicted from our present means of calculation.

In the following diagram I have introduced a sketch of a piece of physical apparatus which illustrates the increase of head away from the leak toward the source of pressure, representing closely the relations which appear in the South Dakota artesian basin, and probably in a measure also those of central and eastern Nebraska. It will be seen that the gradient is a relatively rapid one, but we must bear in

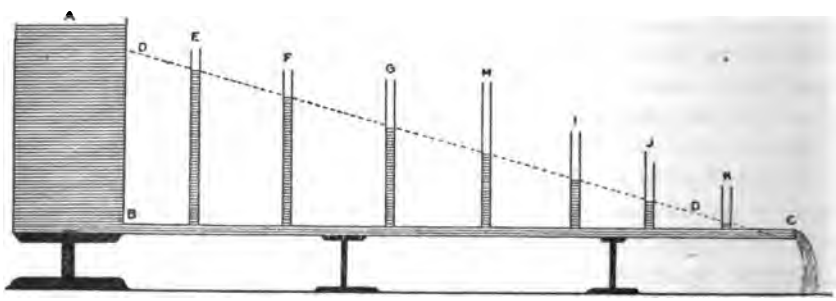


FIG. 13.—Diagram of apparatus for illustrating the declivity of head of liquids flowing from a reservoir.

mind that the distance from eastern Nebraska to the Rocky Mountains is very great and much of the intervening land slopes up to a fairly high altitude. There is another condition which may be adverse. The Dakota sandstone is exceedingly variable in physical character. In Lancaster County and in the belt extending northward to the Missouri River at Dakota City the sandstone is porous, clay is not predominant, and the conditions are favorable for the transmission of large water supplies. It may be that westward the formation becomes finer grained over a greater or less area in such manner as to choke out water. Of this, however, there is no definite evidence. In the outcrops in Jefferson County there is considerable clay admixture, but many of the beds are sufficiently porous to carry the water. The outcrops are found far westward in Kansas, not far south of the Nebraska boundary, and they appear to be coarse and suitable for bearing water.

In the next underlying formation, the Carboniferous limestones, flowing water has been obtained in considerable volume in the wells at

Lincoln, but it is so salty that the wells are more likely to prove useful as sources of salt supply than for anything else. It is probable, however, that this saline water is of relatively local occurrence, occupying a basin under eastern Nebraska, and that farther westward the waters in the Carboniferous formation may be perfectly fresh, or at least only slightly mineralized. It would hardly be safe to offer this as a prediction, but it is worth bearing in mind as as a possibility. At Omaha, northward in Dakota, and eastward in Iowa excellent waters are obtained from Carboniferous limestone. It is therefore desirable to point out the advisability of sinking deep wells in the region west of Seward and Saline counties to test, in the first place, the water resources of the Dakota sandstone, and if these are inadequate, to drill deeper to the underlying formations. The depth to which it would be necessary to go can not be definitely calculated from data now on hand. At Kearney the Pierre shales were reported to extend from a depth of 71 feet to 2,460 feet, the bottom of the boring; but it is believed that the top of the Dakota formation was not far below. Eastward the thickness of Cretaceous shales diminishes gradually as the Dakota and underlying formations rise toward the surface and the land decreases in altitude. Some of these relations are further illustrated in Pl. IV.

FIG. 14.—Record of deep boring at Dannebrog, Howard County, Nebraska.

Owing to the difficulty of sinking a boring in the overlying clays of the Cretaceous formations, expert well drilling will be necessary, and borings should be very large at the top. The experiments will be expensive, but it is hoped that at some such point as Grand Island, Hastings, Kearney, or North Platte an attempt will eventually be made to ascertain the resources of the Dakota sandstone and, if necessary, the underlying formations.

IRRIGATION BY UNDERGROUND WATERS.

At many points in this region the underground waters have been employed for irrigation. In the Beaver Crossing area the artesian flows have been used, but elsewhere the supply has to be lifted to the surface with windmills. In greater part the irrigated areas have been only a very few acres or a garden. Under most of the region there are ample supplies of water for extensive irrigation, but with windmill pumping it usually has not been found practicable to irrigate properly over 10 to 15 acres from one mill. When the waters lie over 75 or 100 feet below ground the amount available is less, for the efficiency of pumping rapidly decreases beyond a moderate depth. Very few irrigators regard artificial watering as profitable for large field crops of low market value, but for small, diversified crops for family subsistence and local sale, and some special crops, such as potatoes, pump irrigation is certain to be appreciated as a necessity in dry seasons and a useful adjunct even in the more rainy ones.

In traveling over the area to which this report relates an endeavor was made to obtain some data in regard to the methods and results of farm well irrigation in the various counties. Information was also gathered in regard to irrigation in the Beaver Crossing artesian basin. The results of these inquiries are set forth in the following pages.

LANCASTER COUNTY.

In this county there is considerable irrigation in a small way, mainly of garden areas. Some experiences of irrigators are as follows:

Mr. H. G. Weber, gardener, west of Lincoln, irrigates garden truck, including onions, radishes, lettuce, spinach, asparagus, pieplant, eggplant, pepper, cabbage, tomatoes, cucumbers, celery, and other vegetables. His well is 60 feet deep, but the water rises to within 26 feet of the surface. The pump has a 3-by-10 cylinder. The reservoir is on the highest land and has a capacity of 1,000 barrels. In a good wind the pump supplies 10 to 12 barrels per hour. Mr. Weber states that, although his plant is small, the results have been very satisfactory.

Mr. E. H. Cushman, near Lincoln, states that he has been irrigating a market garden for two years. He has a 12-foot aermotor windmill, which runs a pump with 6-inch cylinder and a 12-inch stroke, raising about 2 gallons of water to the stroke. The well is about 32 feet deep, with approximately 14 feet of water, in large supply. The reser-

voir is 50 by 100 feet and 4 feet deep. Can irrigate 10 acres. Has also built a "Jumbo" mill to run two pumps with 3-inch cylinders, 12-inch stroke.

Mr. E. E. Smith, near Lincoln, irrigates 5 acres, mainly of garden truck. He has a well 25 feet deep, containing 12 feet of water. His reservoir is 50 feet square. Water is pumped with a 5-foot aermotor.

SEWARD COUNTY.

In the artesian area along Blue River, in the vicinity of Beaver Crossing, the waters have been used by a number of farmers for irrigation of small areas. The results have been very satisfactory, and the disposition to introduce irrigation in this area is growing in a most encouraging manner. Only a few facts have been obtained in regard to irrigation plants and results.

Mr. J. T. Godding has a well which is 105 feet deep, 3 inches in diameter, and yields 125 gallons per minute, which will rise to 25 feet above the surface. He irrigates, with good results, a field 40 rods square, which is flooded directly from the wells.

M. M. Martson, near Beaver Crossing, irrigates 10 acres with artesian waters in dry seasons. He has a 3-inch well, 100 feet deep, and the water rises 20 feet above ground. The reservoir is 2 rods wide by 40 rods long and 8 feet deep.

Messrs. Horney and Evans have two flowing wells, with water at depths of 90 to 100 feet, which rises 15 feet above ground. They are 3 inches in diameter and flow 100 gallons each per minute. In dry seasons they irrigate potatoes.

Mr. Thomas Wilson, near Beaver Crossing, has a 4-inch flowing well, 125 feet deep. The water rises 5 feet above ground. His reservoir is 40 by 60 feet. Three acres of potatoes irrigated in 1896 yielded twice the product obtained from adjoining fields not irrigated.

Mr. Thomas Trilzman, near Beaver Crossing, irrigates from a flowing well. His reservoir is 100 by 50 feet and 6 feet deep. His corn yielded 85 bushels and prairie grass 2 tons per acre. Sugar beets were found to be greatly benefited by the water.

Mr. F. M. Dimery, near Beaver Crossing, has nine flowing wells on his farm, of which the average depth is 100 feet. Four of them are 3-inch pipe, and flow about 150 gallons per minute. Two of the wells have been used for irrigating 60 acres of land direct from the wells in small ditches made with a plow. Mr. Dimery has also irrigated a 2-acre garden and 6 acres of meadow.

On the Fountain Head Experimental Farm, near Beaver Crossing, Mr. T. C. Ferguson has irrigated extensively by artesian waters.

Mr. J. W. Arasmith has wells near Beaver Crossing, and a half-acre reservoir with 4-foot banks, but has not as yet irrigated.

Mr. M. Powell irrigates a small area of bottom land from his flowing well.

FILLMORE COUNTY.

Mr. J. H. Little, near Fairmont, has irrigated to some extent. He has two bored wells, 70 feet deep. His pumps are 8½ by 16 inch cylinders, and 1½-inch pipe is used. A 12-foot windmill works both pumps, yielding from 10 to 20 barrels per hour. He irrigates 5 acres of orchard in the autumn and winter, and estimates that the yield was about doubled by irrigation. His reservoir is 30 by 150 feet.

YORK COUNTY.

Mr. L. D. Stilson, near York, is irrigating from two small ponds. One is 25 by 40 feet, carrying 30 inches of water, supplied from the overflow of house well, 40 feet deep, pumped by windmill. The overflow is used for lawn and shrubbery. The other pond is 40 by 100 feet and contains 4 feet of water, supplied by a 4-inch pump with windmill from a well 40 feet deep. During January and February he pumped water directly onto a little more than an acre of strawberries, with very satisfactory results. He is planning to put in a third pond, 75 by 200 feet, pumping the water 75 feet, to supply apple, peach, and cherry orchards.

Mr. F. E. Porter, at McCool Junction, has irrigated from a pond 70 feet in diameter, 5 feet deep, and capacity of 4,000 barrels. He employs a 12-foot Eclipse mill, with 5-inch cylinder, which pumps 1,000 barrels in twenty-four hours, in a good, steady wind. He employs hose of 10-ounce oiled ducking for distribution of water. His results in irrigation of garden truck have been most satisfactory. Many other persons irrigate small truck patches with ordinary windmill pump.

HAMILTON COUNTY.

Mr. G. L. Cushman, near Chapman, is irrigating with considerable success. He employs a Dempster vaneless 16-foot mill, with 8-inch cylinder and pipe. It is 32 feet from surface to bottom of screen, and the water level can not be pumped down. The reservoir is 110 feet in diameter, and is located on a portion of the land which is slightly higher than the adjacent fields. His ditches are dug, with banks of the excavated material. Potatoes have been the crop, but the plant as it now stands will hardly supply water enough for 5 acres in dry seasons. Irrigation was found to increase the crop to a very notable degree, but no precise figures are offered.

BUFFALO COUNTY.

Mr. Joseph Buck, near Shelton, irrigated about 1 acre of potatoes in 1895. His well is 25 feet deep, and with his present pumping arrangements yields about 150 gallons per minute in a fair wind. The supply appears to be inexhaustible. His reservoir is one-half acre in size.

Mr. W. K. Wright, near Gibbon, irrigates from a reservoir 1 acre in area, with banks about 5 feet high on the outside. The water supply is from two 12-inch pumps operated by two 16-foot windmills, each pump delivering about 130 gallons per minute in a fair wind. The water level is 10½ feet below the surface. One of the pumps draws the water from eight 3-inch pipes radiating from a chamber which fastens to the bottom of the cylinder. Each of the radiating pipes is 4 feet long, the outer ends connecting with elbows to perpendicular pipes with gauze points driven 12 feet into the water. The other pump is supplied from an open well 54 feet deep, 16 inches in diameter, with 700 three-quarter inch auger holes, covered with gauze, near the bottom. The largest volume of water is in gravel 18 feet thick, beginning 10½ feet below the surface. Below this the water contained too much quicksand. Mr. Wright has found that flooding the land in the autumn and winter is very beneficial to the crops of the ensuing season. In 1895, 20 acres of corn were irrigated once, at earing time, with the gratifying result of doubling the crop over that of adjoining nonirrigated lands. He has raised 150 bushels of potatoes per acre. His main ditches are 2½ to 4 feet wide, according to the slope of the ground. The land does not carry water well for long distances. He thinks he can depend on irrigating 25 acres, with water to spare some seasons for the further irrigation of from 15 to 20 acres more.

Mr. R. M. Jones, near Elm Creek, irrigates with a Dempster mill, 16-foot wheel, pumping from eight 3-inch points driven from the bottom of a hole 8 feet deep, 11 feet in diameter, into water-bearing gravels below. He has been able to wet about 25 to 30 acres by running the water out over the frozen ground. Corn, wheat, barley, and oats yielded very fine crops, which, however, were seriously damaged by hail before harvesting.

DAWSON COUNTY.

Along the valley of the Platte in this county irrigation from shallow wells by windmills has been practiced at several localities. Information could be procured from only a few of the irrigators. The following statements are representative:

Mr. G. Malchow, near Lexington, irrigates from a 20-foot well with pumping outfit and reservoir situated on a low knoll, which is about 8 feet higher than adjoining portions of the farm. The pump consists of an 8-inch pipe, 20 feet long, with two laterals, 2 inches in diameter, driven down 19 feet deep into the water-bearing beds. The first water is 21 feet from the top of the knoll, in a bed of gravel 2 feet thick, underlain by 10 to 12 inches of clay and sand, below which are other water-bearing gravels. The reservoir is 6 feet deep, 150 feet long, and 100 feet wide. In 1895 the wind had sufficient force to keep this reservoir about full from March to the 1st of July. Two acres were planted in potatoes and 1 acre in a variety of garden truck,

including lettuce, onions, beets, carrots, cabbage, etc. The water was turned into these fields about twice a week, and the products were large and fine. Owing to lack of market, however, the operation was not a profitable one. In the middle of June, Mr. Malchow irrigated 2 acres of potatoes, and these yielded, on harvesting, about 100 bushels to the acre. Potatoes in the adjoining fields not irrigated made practically no crop at all. There were also irrigated 2 acres of oats, which made 40 bushels to the acre, while other oats in the vicinity made only 10 bushels. By comparing results with neighbors who apply the water direct from the wells, it was found that storage in reservoirs is very necessary, both to gain sufficient volume for irrigation and to allow the water to acquire the proper temperature.

Mr. G. Ballmer, near Gothenburg, has a Dempster irrigation outfit, consisting of 8-inch pump, 30-foot tower, and 16-foot open wheel. The well is 40 feet deep, 8 feet wide, and has six 2-inch pipes 29 feet long, with sand points which are driven down into the gravel. They connect in the bottom of the well with an 8-inch cylinder. He estimates that by running the pump continuously he could irrigate 20 to 30 acres. His reservoir is 60 by 200 feet, with banks about 4 feet high. At present he is irrigating only in a small way—fruit trees, truck patch, a few acres of potatoes, and 5 acres of corn.

Mr. Alex. I. Johnson, near Lexington, makes the following statement: He has an 8-inch pump with six 2-inch pipes attached. The water level is 14 feet below the surface and the supply is very large. With a 10-inch stroke his mill pumps about 100 gallons per minute. The reservoir is 100 feet long by 60 wide, and holds water sufficient for about 2 acres at a time. From this plant he has irrigated from 10 to 12 acres, which have yielded good crops during seasons when the crops failed completely on nonirrigated land. His potatoes have yielded 110 bushels, corn 40 bushels, while in nonirrigated areas only 15 bushels were obtained last season.

Mr. L. A. Lewis, near Cozad, gives the following particulars in regard to his irrigation operations: His well is 20 feet by 8 feet, with six sand points driven 10 feet below and connected with an 8-inch cylinder. The water level is 22 feet below the surface. His windmill is 16 feet in diameter and has a 10-inch stroke. He believes that with a sufficiently large reservoir, in a moderately windy season, he could irrigate from 50 to 60 acres. He has not, however, built a reservoir. During the last two seasons he has raised potatoes, onions, and other vegetables. In the season of 1896 he raised 250 bushels of onions on 30 square rods. His potatoes yielded 250 bushels per acre in 1895. On adjoining fields not irrigated the potato crop was practically nothing. He realizes the necessity of having a reservoir to furnish the water in sufficient volume and at the proper temperature.

Mr. Oliver Miller, near Cozad, has a plant to irrigate about 5 acres in the Platte Valley. His well is 45 feet deep and contains the usual

large water supply. His windmill raises about 25 gallons per minute under a favorable wind. The reservoir is 5 rods square and holds 4 feet of water. His crops have been potatoes and garden truck, of which the yield is about doubled by irrigation.

Mr. A. F. Velt, near Lexington, irrigates from 10 to 15 acres in dry seasons. His well is 62 feet deep and the windmill a 16-foot Dempster. The reservoir, 60 by 100 feet in area and 4 feet deep, can be filled in about four days with a 6-inch stroke. Mr. Velt reports very satisfactory results with potatoes, onions, cabbage, corn, and miscellaneous garden truck.

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1895.

Sixteenth Annual Report of the United States Geological Survey, 1894–95, Part II, Papers of an economic character, 1895, octavo, 598 pp.

Contains a paper on the public lands and their water supply, by F. H. Newell, illustrated by a large map showing the relative extent and location of the vacant public lands; also a report on the water resources of a portion of the Great Plains, by Robert Hay.

A geological reconnoissance of northwestern Wyoming, by George H. Eldridge, 1894; octavo, 72 pp. Bulletin No. 119 of the United States Geological Survey; price, 10 cents.

Contains a description of the geologic structure of portions of the Big Horn Range and Big Horn Basin, especially with reference to the coal fields, and remarks upon the water supply and agricultural possibilities.

Report of progress of the division of hydrography for the calendar year 1893–94, by F. H. Newell, 1895; octavo, 176 pp. Bulletin No. 131 of the United States Geological Survey; price, 15 cents.

Contains results of stream measurements at various points, mainly within the arid region, and records of wells in a number of counties in western Nebraska, western Kansas, and eastern Colorado.

1896.

Seventeenth Annual Report of the United States Geological Survey, 1895–96, Part II, Economic geology and hydrography, 1896; octavo, 864 pp.

Contains papers on "The underground water of the Arkansas Valley in eastern Colorado," by G. K. Gilbert; "The water resources of Illinois," by Frank Leverett; and "Preliminary report on the artesian waters of a portion of the Dakotas," by N. H. Darton.

Artesian-well prospects in the Atlantic Coastal Plain region, by N. H. Darton, 1896; octavo, 230 pp., 19 plates. Bulletin No. 138 of the United States Geological Survey; price, 20 cents.

Gives a description of the geologic conditions of the coastal region from Long Island, N. Y., to Georgia, and contains data relating to many of the deep wells.

Report of progress of the division of hydrography for the calendar year 1895, by F. H. Newell, hydrographer in charge, 1896; octavo, 356 pp. Bulletin No. 140 of the United States Geological Survey; price, 25 cents.

Contains a description of the instruments and methods employed in measuring streams and the results of hydrographic investigations in various parts of the United States.

1897.

Eighteenth Annual Report of the United States Geological Survey, 1896–97, Part IV, Hydrography, 1897; octavo, 756 pp.

Contains a "Report of progress of stream measurements for the calendar year 1896," by Arthur P. Davis; "The water resources of Indiana and Ohio," by Frank Leverett; "New developments in well boring and irrigation in South Dakota," by N. H. Darton; and "Reservoirs for irrigation," by J. D. Schuyler.

Water Supply and Irrigation Papers.

This series of papers is designed to present in pamphlet form the results of stream measurements and of special investigations. A list of these, with other information, is given on the outside (or fourth) page of this cover.

Survey bulletins can be obtained only by prepayment of cost, as noted above. Postage stamps, checks, and drafts can not be accepted. Money should be transmitted by postal money order or express order, made payable to the Director of the United States Geological Survey. Correspondence relating to the publications of the Survey should be addressed to **The Director, United States Geological Survey, Washington, D. C.**

WATER-SUPPLY AND IRRIGATION PAPERS.

1. Pumping water for irrigation, by Herbert M. Wilson, 1896.
2. Irrigation near Phœnix, Arizona, by Arthur P. Davis, 1897.
3. Sewage irrigation, by George W. Rafter, 1897.
4. A reconnoissance in southeastern Washington, by Israel C. Russell, 1897.
5. Irrigation practice on the Great Plains, by E. B. Cowgill, 1897.
6. Underground waters of southwestern Kansas, by Erasmus Haworth, 1897.
7. Seepage waters of northern Utah, by Samuel Fortier, 1897.
8. Windmills for irrigation, by E. C. Murphy, 1897.
9. Irrigation near Greeley, Colorado, by David Boyd, 1897.
10. Irrigation in Mesilla Valley, New Mexico, by F. C. Barker, 1898.
11. River heights for 1896, by Arthur P. Davis, 1897.
12. Water resources of southeastern Nebraska, by Nelson Horatio Darton, 1898.
13. Irrigation systems in Texas by W. F. Hutson, 1898.
15. Operations at river stations, 1897, Part I, 1898.
16. Operations at river stations, 1897, Part II, 1898.

In press:

14. New tests of certain pumps and water lifts used in irrigation, by O. P. Hood, 1898.

In addition to the above, there are in various stages of preparation other papers relating to the measurement of streams, the storage of water, the amount available from underground sources, the efficiency of windmills, the cost of pumping, and other details relating to the methods of utilizing the water resources of the country. Provision has been made for printing these by the following clause in the sundry civil act making appropriations for the year 1896-97:

Provided, That hereafter the reports of the Geological Survey in relation to the gauging of streams and to the methods of utilizing the water resources may be printed in octavo form, not to exceed 100 pages in length and 5,000 copies in number; 1,000 copies of which shall be for the official use of the Geological Survey, 1,500 copies shall be delivered to the Senate, and 2,500 copies shall be delivered to the House of Representatives, for distribution. [Approved June 11, 1896; Stat. L. vol. 29, p. 453.]

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DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 13

IRRIGATION SYSTEMS IN TEXAS.—HUTSON

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

IRRIGATION REPORTS.

The following list contains titles and brief descriptions of the principal reports relating to water supply and irrigation prepared by the United States Geological Survey since 1890:

1890.

First Annual Report of the United States Irrigation Survey, 1890; octavo, 123 pp.

Printed as Part II, Irrigation, of the Tenth Annual Report of the United States Geological Survey, 1888–89. Contains a statement of the origin of the Irrigation Survey, a preliminary report on the organization and prosecution of the survey of the arid lands for purposes of irrigation, and report of work done during 1890.

1891.

Second Annual Report of the United States Irrigation Survey, 1891; octavo, 395 pp.

Published as Part II, Irrigation, of the Eleventh Annual Report of the United States Geological Survey, 1889–90. Contains a description of the hydrography of the arid region and of the engineering operations carried on by the Irrigation Survey during 1890; also the statement of the Director of the Survey to the House Committee on Irrigation, and other papers, including a bibliography of irrigation literature. Illustrated by 29 plates and 4 figures.

Third Annual Report of the United States Irrigation Survey, 1891; octavo, 576 pp.

Printed as Part II of the Twelfth Annual Report of the United States Geological Survey, 1890–91. Contains "Report upon the location and survey of reservoir sites during the fiscal year ended June 30, 1891," by A. H. Thompson; "Hydrography of the arid regions," by F. H. Newell; "Irrigation in India," by Herbert M. Wilson. Illustrated by 98 plates and 190 figures.

Bulletins of the Eleventh Census of the United States upon irrigation, prepared by F. H. Newell; quarto.

No. 35, Irrigation in Arizona; No. 60, Irrigation in New Mexico; No. 85, Irrigation in Utah; No. 107, Irrigation in Wyoming; No. 153, Irrigation in Montana; No. 157, Irrigation in Idaho; No. 168, Irrigation in Nevada; No. 178, Irrigation in Oregon; No. 193, Artesian wells for irrigation; No. 198, Irrigation in Washington.

1892.

Irrigation of western United States, by F. H. Newell; extra census bulletin No. 23, September 9, 1892; quarto, 22 pp.

Contains tabulations showing the total number, average size, etc., of irrigated holdings, the total area and average size of irrigated farms in the subhumid regions, the percentage of number of farms irrigated, character of crops, value of irrigated lands, the average cost of irrigation, the investment and profits, together with a résumé of the water supply and a description of irrigation by artesian wells. Illustrated by colored maps showing the location and relative extent of the irrigated areas.

1893.

Thirteenth Annual Report of the United States Geological Survey, 1891–92, Part III, Irrigation, 1893; octavo, 486 pp.

Consists of three papers: "Water supply for irrigation," by F. H. Newell; "American irrigation engineering" and "Engineering results of the Irrigation Survey," by Herbert M. Wilson; "Construction of topographic maps and selection and survey of reservoir sites," by A. H Thompson. Illustrated by 77 plates and 119 figures.

A geological reconnoissance in central Washington, by Israel Cook Russell, 1893; octavo, 108 pp., 15 plates. Bulletin No. 108 of the United States Geological Survey; price, 15 cents.

Contains a description of the examination of the geologic structure in and adjacent to the drainage basin of Yakima River and the great plains of the Columbia to the east of this area, with special reference to the occurrence of artesian waters.

1894.

Report on agriculture by irrigation in the western part of the United States at the Eleventh Census, 1890, by F. H. Newell, 1894; quarto, 283 pp.

Consists of a general description of the condition of irrigation in the United States, the area irrigated, cost of works, their value and profits; also describes the water supply, the value of water, of artesian wells, reservoirs, and other details; then takes up each State and Territory in order, giving a general description of the condition of agriculture by irrigation, and discusses the physical conditions and local peculiarities in each county.

Fourteenth Annual Report of the United States Geological Survey, 1892–93, in two parts; Part II, Accompanying papers, 1894; octavo, 597 pp.

Contains papers on "Potable waters of the eastern United States," by W. J. McGee; "Natural mineral waters of the United States," by A. C. Peale; "Results of stream measurements," by F. H. Newell. Illustrated by maps and diagrams.

(Continued on third page of cover.)

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 13

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

IRRIGATION SYSTEMS IN TEXAS

BY

WILLIAM FERGUSON HUTSON

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, November 26, 1897.

SIR: I have the honor to transmit herewith a paper entitled Irrigation Systems in Texas, by William Ferguson Hutson, and to recommend that it be published in the series of pamphlets on Water-Supply and Irrigation. This manuscript was prepared in accordance with a request made to Prof. J. H. Connell, director of the Texas Agricultural Experiment Station. Professor Connell found that it was impossible for him to give the necessary time to field investigation and the preparation of a report of results, and therefore recommended that the work be intrusted to Mr. Hutson. The field work was carried on during May and June of 1897; the paper was written during July and transmitted early in August. The data were necessarily accumulated in a relatively short time, and the author considers the paper somewhat in the light of a preliminary report. A number of illustrations used in this paper have been obtained through the courtesy of Mr. Robert T. Hill, geologist of this Survey, from his paper in Part II of the Eighteenth Annual Report.

In the preparation of this manuscript for publication considerable liberty has been taken with the arrangement and the manner of presentation. While the statements of fact have been preserved, such changes have been made in the character of the paper as seemed necessary to bring it into harmony with the series as a whole. In particular a somewhat arbitrary geographic arrangement has been adopted in place of one based on considerations of quantity of rainfall, as it appeared undesirable to make the assumption that irrigation is governed by questions of mean annual precipitation.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

RUN-OFF OF SAN MARCOS SPRING.

INTRODUCTION.

By F. H. NEWELL.

In the report upon Agriculture by Irrigation, prepared for the Eleventh Census, 1890, all the facts obtainable at that time concerning irrigation in Texas were presented and discussed. It was found by the enumeration that there were in the whole State 623 persons irrigating farms, having an aggregate area of 18,241 acres, or an average of 29 acres irrigated by each person. This did not include the smaller kitchen and flower gardens, of which there were probably hundreds, or even thousands, watered by means of city supply or windmills. The definition of "a farm," adopted for the purpose of the census, included "all staple nurseries, orchards, and market gardens owned by separate parties which were cultivated for pecuniary profit and which employed as much as the labor of one able-bodied workman during the year." The land which was irrigated formed on an average only 2.43 per cent of each farm, showing that irrigation where used was practiced on only an inconsiderable portion of each landowner's holding.

Since 1890 there has been considerable progress made in the development of irrigation, and interest has been stimulated by the success recently attained in various localities. This later investigation in Texas has, therefore, been made for the purpose of procuring fresh information, especially concerning the recent developments. The facts are of interest not only to the people of that State, but to a less degree to those of the whole United States, for Texas embraces such a wide range in topography and climate that success attained within its boundaries suggests the advisability of the same line of action in some other locality. On account of this great diversity of natural conditions, irrigation has been developed along many different lines. Not only is water diverted from creeks and larger rivers, but in some localities it is held by storage, in others it is pumped from ordinary wells, and in still others it is obtained from artesian wells. Where the conditions are favorable, the swiftly flowing streams are employed in pumping a portion of their own water up to the top of the adjacent banks, or the ever-present winds of the prairies are utilized by means of windmills to bring a needed supply of moisture from far underground. In short, in the broad stretch of country from the humid

lands on the east to the arid region on the west, from the semitropic glades of the south Gulf coast to the high plains of the interior, is to be found almost every variety of physical condition and of mechanical device for supplying needed water to the soil.

When we consider the State of Texas—in area nearly a tenth of the whole United States, and with a population less than that of the little State of Massachusetts, sparsely scattered even in the humid portion, with enormous areas of rich soil but poorly tilled—the question arises, Why should irrigation be practiced? Agriculture by this method is necessarily intensive farming—a method which should be practiced amid a dense population, and one where success is attained only by thorough tilling and careful attention to details. Why then should this be taken up in a State where fertile land is so cheap and where great areas have not been touched by the plow? The answer lies in the fact that many farmers are beginning to discover that larger profits can be made by carefully tilling a small area than by attempting to diffuse their efforts over plantations of considerable size, and that in order to produce the largest yield from a given outlay of time and labor it is necessary to insure the presence of sufficient moisture at the right time. This lesson, however, has not been universally learned. The education of the great majority of farmers or planters has been such as to make them adhere to old methods, and often it is only after object lessons have been many times repeated that they are willing to concede that their broad farming is not the most profitable.

Included within the State of Texas are lands upon which irrigation was practiced as early as, if not earlier than, in any other portion of the United States, and it would thus seem that this method of agriculture should have spread and be more generally practiced than it is. It is a fair question, Why, if irrigation is so profitable, has it not become the rule rather than the exception? The answer can probably be found in the character and training of the population and in the unfriendly attitude of the laws of the State toward the development of irrigation works. The very extent of the State—the enormous areas of land that might be had almost for the asking—has tended to make the farmer look down upon little methods and disregard the small economies and the attention to detail so essential in intensive agriculture. Thus the tendency has been to leave irrigation to the Mexican, who originally practiced it, and to regard it as something almost unworthy of the consideration of a "white man." The time has come, however, for a change in general sentiment. A more diversified farming has been introduced, together with better methods, brought in to a certain extent by immigration from other States. The rapid growth of the Territories to the northwest, which are dependent for their agriculture upon irrigation, has stimulated a desire and an endeavor to attain like results by similar means, and opportunities which before have been neglected are being seized upon.

Before any considerable development can take place in irrigation, upon either a large or a small scale, facts must be known concerning the water supply. If this is to be obtained from a river, it must be known whether the low-water flow is sufficient for the purpose and whether the floods are of such size as to sweep away structures which should be permanent. Even in the case of individuals intending to pump water from the ground, questions are first asked as to whether the ground water is sufficient in volume and whether it can be obtained at a depth near enough to the surface to be profitably raised. The answer to all questions of this kind must come primarily through a comprehension of the geology of the country. Ignorance of the volume of some of the larger streams has already resulted in serious disappointment, and probably in heavy loss, to several large enterprises, and it is probable that other works of this character will not be carried out until the investors have a better knowledge of the physical conditions, of drought, and of high water. From a knowledge of the underground conditions it is possible to foretell the depth to the water-bearing strata and the general character of these, and to base estimates upon the quantity which may be obtained by properly constructed wells. Matters of this kind must be investigated if the resources of the country are to be neither underestimated and neglected nor overstated and made the basis of loss to credulous investors.

With the measurement and study of surface streams and the accumulation of facts concerning the underground structure, with reference to the amount and quality of the water available, there are closely joined considerations of methods and cost of lifting the water up to the lands to be irrigated. No general rule can be laid down as to how much any given individual can afford to expend in obtaining a water supply for irrigation. Each case must be considered on its own merits, alike as to methods and machinery, the amount of water needed, and the character and ultimate value of the crop. As a general rule it may be said that for the field crops as ordinarily cultivated irrigation, especially by pumping, will not pay; but in diversified farming, where personal attention is given by the owner to every detail, expensive methods of storing or pumping water have in the long run been found highly profitable. In order to bring out the divergence in practice there have been assembled in the following table the more important facts obtainable concerning the cost of water by the various methods described in the following pages.

This table gives in the first column the page upon which the irrigation system is described and in the next column the name in abbreviated form. In the third column are a few words to indicate the character of the system—whether the ordinary canal or ditch diverting water from a river by means of a dam, or a mechanical device, such as a windmill or pumps driven by steam or gasoline. In the next column is given the lift in feet where water is raised by pumping,

and next to this the capacity of the pump or ditches in cubic feet per second. This column also gives the total amount delivered in acre-feet in 12.1 hours, since 1 cubic foot per second flowing for this length of time will cover 1 acre a foot in depth. To the acreage two columns are devoted—the first giving the total area irrigable, or the amount which it is estimated each system will cover; and the second, the area actually watered, this applying usually to the year 1896. Beyond this is given the total cost of the system, and, wherever practicable, the cost per acre. This latter column, in the case of the larger ditches, shows the amount asked or paid per acre for water rights. The last column gives the estimated annual cost per acre for water, figures for this being rarely obtainable.

Comparison of capacity and cost of various systems of water supply in Texas.

Page.	Name.	System.	Pump.	Lift in feet.	Capacity, second-feet.	Acreage.		Cost.		
						Irrigable.	Irrigated.	Total.	Per acre.	Annual per acre.
26	Catron	50 H. P. engine.	Menge	8	11.14		500	$1,500	$3	
29	Stubenrauch	8-foot windmill.		25		15	7	300	43	
29	do	12-foot windmill. *a*				30		485	16	
31	Lytle	Dam and ditch				300		25,000		
31	Lewis	do				50	10	200	20	
31	Metcalf	do					470		7	$0.75
32	Glenn	do				350	250	3,500	14	
32	McGee	do				250	75	1,500	20	
32	Swinden	80 H. P. *b*	Centrifugal		6.84	400				
33	Baker	32 H. P. engine. *d*	Worthington.		2.72	80	75	2,000	27	*c* 6.00
33	Willis	Turbine			.11		5			
33	Alldridge	20 H. P. engine. *e*			1.00	75				
33	Lindsey	30 H. P. engine. *f*			1.87		40	2,000	50	
34	Vanderstucken	18 H. P. engine.	Menge		2.60		100	1,500	15	
39	Richards	Water wheel			.20		3			
39	Garrett	do			.32		12			
43	Upper Labor	Ditch				600	100			2.00
46	Trueheart	Ditch *g*			30.00	1,500	400	18,000	15	2.50
46	Kampman	Artesian well.			2.32	1,000	250	3,000		
47	Pickett	40 H. P. boiler. *h*	Blakeslee	50	1.67	400	100	2,500		*c* 4.00
48	Crandall	10 H. P. boiler. *i*	Blake	48	.20			295		
49	Simmons	2½ H. P. gasoline.			.07		10	450		
49	Experiment	5½ H. P. gasoline.		48	.05	20				
55	Grover	100 H. P. boiler *j*	Menge	48	14.00	500	70	5,000		1.00

a Combined water power and irrigation.
b With reservoir.
c Approximate.
d Operating cost, $7 a day of twelve hours.
e Can water 5 acres per day.
f Operating cost, $3 per day of eleven hours.
g Water rights held at $15.
h Costs 12½ cents per hour to operate.
i Pumps into reservoir.
j Operating expenses, $4.25 per day.

Comparison of capacity and cost of various systems of water supply in Texas—Continued.

Page.	Name.	System.	Pump.	Lift in feet.	Capacity, second-feet.	Acreage.		Cost.		
						Irrigable.	Irrigated.	Total.	Per acre.	Annual per acre.
56	Miller	40 H. P. boiler	Double	39	.29	140	70	$3,000		
56	Del Rio	Dam and ditches.					3,600	25,000		$0.50
58	Urbahn	80 H. P. boiler	Pulsometer	65	1.11	125	50			
58	Sterneberg	Windmill					3	220		
58	Charleston	12-foot windmill. *a*		30			5	425		
59	Closner	25 H. P. engine	Centrifugal		10.58		100			
59	Rabb	50 H. P. boiler	Menge	18	20.00		200	2,000		
59	Brulay	100 H. P. boiler	Centrifugal	22	17.82	300	200			
59	Goodrich	14-foot windmill.		10			18	300		
60	Wayland	3 windmills		50		25		505		
60	Murray	8-foot windmill. *a*		124			1½	222		
63	Margueretta	Dam and ditch				40,000	6,000	150,000	$10	1.50
64	Pecos R. I. Co	do				20,000	600	35,000	5	.50
64	Grand Falls	do							15	1.25
65	El Paso					30,000	3,000	220,000		2.00

a With reservoir.

In looking over this statement probably the first observation that one will make is the wide diversity of costs and results. This is partly accounted for by the fact that these figures are for the most part mere estimates and are open to the suspicion of being exaggerated to serve individual interests in one case or another. In particular the volume or capacity of the ditches is usually overstated, and concerning the pumps very little is known beyond the maker's estimates, prepared for the purposes of selling his machinery. Judging from these and similar statements, the first and annual cost of water from the large ditches is very low, being from $10 to $15 per acre for water rights and from 50 cents to $1.50 per acre for annual maintenance. The cost of water per acre by pumping is usually much more, and may range from $20 to $50 per acre, or even higher.

The small cost of water from gravity ditches in Texas, as well as in other States, is more apparent than real. As a rule the larger canal companies base their selling price for water rights upon the assumption that the work will cost a certain sum and that several thousand acres will be irrigated and subsequently sold. In this assumption the corporations have often been disappointed, the work costing far more than anticipated and the sales of water right with or without land being exceedingly slow. The promoters have appreciated the fact that these lands can not be sold unless the first and the annual cost of water is kept down to the lowest figure. The struggle to maintain

the property upon the small returns has often resulted in the system going into bankruptcy or being kept in very poor condition. Sometimes, also, the estimated supply of water has not been sufficient; and thus, from one cause or another, the landowners, although nominally paying a small price for their water rights and for the annual maintenance of these, in point of fact ultimately pay a very large price for an insufficient supply. This should be borne in mind in making comparisons between the cost of water as usually given by irrigation companies and the outlay required in the case of pumping machinery.

The expense of lifting water for irrigation must, as a rule, be far greater than that of diverting a supply by gravity, but in many places circumstances or conditions are such that the former is the only method practicable. Where considerable areas are watered and the lift is small the extra cost may be more than compensated by the convenience and the possibility of controlling the source of supply. The pumping plant as a means of insurance against drought, even in humid regions, is coming to be recognized as a good investment. If properly protected from the weather it may stand for months or years without use, ready in times of deficient rainfall for immediate service in saving a crop that otherwise would be a failure.

One of the notable features in connection with pumping is the apparently low efficiency attained when one compares the amount of water which it is claimed a pump delivers with the acreage actually cultivated. Two reasons for this are apparent: The first is that the pumps may not be run to their full capacity or the water may not be used upon as large an area of ground as possible. But the principal reason often lies in the fact that the capacity of the pump is greatly overrated, and few purchasers ever make systematic tests of the amount of water actually delivered. Many disappointments have resulted from farmers attempting to irrigate with too small a volume of water. They have assumed that the pumps were delivering a certain quantity, say 2 cubic feet per second, when in fact they were raising on the average only one-third or one-quarter of this. It is almost impossible to judge by the eye as to the amount when flowing in a pipe or trough, and they have declared that the ground was not favorable for irrigation when in reality they were trying to accomplish the impossible feat of spreading water from a stream too small to traverse the ground. The real source of trouble has not been with the soil or the method, but with the insufficient supply. This difficulty might be remedied by the construction of a small reservoir or tank, into which the pumped water could accumulate for a few hours and from which a stream of considerable volume could be drawn when an application of water to the soil was to be made. This has often been neglected, to the detriment of the owner.

The amount which can be reasonably expended per acre in procur-

ing a water supply for irrigation is, as stated above, a problem for which no general rule can be given. Much depends upon the character of the crop, and particularly upon the price for which it sells. If there is always a good market for the produce, the next consideration is the skill of the irrigator. The man who is thoroughly experienced in applying water, using only the proper amount, can often afford to pay twice as much for it as can his neighbor who uses a greater quantity and obtains a smaller yield.

The quantity of water needed varies so widely that broad assumptions must be made in order to prepare any estimate of cost. Under ordinary circumstances it may be said that an amount of water equaling 12 inches in depth is sufficient in Texas for a crop season. In other words, an acre-foot of water, or 43,560 cubic feet, will irrigate an acre. A pump delivering at the rate of a cubic foot per second, or 448 gallons per minute, will give nearly 1 acre-foot in twelve hours. Assuming that this water can be held in a reservoir and that the pump is run daily for one hundred days, it should irrigate 100 acres. The cost of water rights where the supply is assured may be taken safely at $15 per acre, or for 100 acres at $1,500. This amount under these assumptions would be a fair allowance for the cost of a pumping plant.

The annual cost of maintenance of works where the water is carefully used may range from $1.50 to $2 per acre. If the pump above mentioned furnishes through the season water at the rate of 1 acre per day, the cost of operating should not exceed this amount—$1.50 to $2. This sum is relatively small for fuel and repairs, and could not be made to include attendance, and therefore it is necessary or desirable that the pumping machinery should be nearly automatic and not require constant attention. These conditions are almost impossible of attainment. Any such statement, therefore, serves as a standard for ideal conditions rather than as an example of what may be realized.

The growth of irrigation in Texas has been retarded not so much by the character of the climate or soil, or by any natural condition, as by artificial obstacles, partly legal but consisting mainly in the lack of training of the farming population. What is needed here, as in most parts of the Great Plains region, is men who know how to irrigate—how to produce the best results under given conditions. In the arid regions, where farming without irrigation is impossible, men learn the business thoroughly; but where a small amount of success can be attained by the careless tilling of large areas the farmers are apt to go on year after year following the old ways, getting a crop when the seasons are good and trusting to chance, hoping in years of drought that the next season will be better.

By the development of small irrigation works in various parts of the State farmers are becoming accustomed to the use of water and

are appreciating the benefits to be derived from having an assured amount of water. It will be necessary, however, for these small plants to multiply many times before the construction of large works can be undertaken with fair assurance of financial success. When by the multiplication of small pumping plants in various localities a considerable body of successful irrigators has been established, it will be possible to construct great canals from the larger rivers, bringing water to thousands of acres of rich lands, and to dispose of water rights at remunerative prices. The small pumping plants may therefore be considered as the necessary forerunners of more economical and efficient systems which will render possible a dense population along the fertile valleys where now farming is precarious and often unprofitable.

IRRIGATION SYSTEMS IN TEXAS.

By WILLIAM FERGUSON HUTSON.

GENERAL STATEMENT.

During the last few years general interest has been aroused in irrigation, and its importance to many portions of Texas is being better appreciated. At this time a discussion of the development of irrigation and its present condition may afford instructive suggestions not only to citizens of the State, but to persons in other parts of the country. The variety of geologic and climatic conditions and the mixed population have given rise to many methods of practice, so that in Texas there may be found representatives of nearly every system of irrigation occurring in the United States. Every degree of excellence may be noted, from that of modern machinery for raising water down to the most primitive devices for supplying it to the field. In the arid and semiarid portions of the State the methods of the early Spanish settlers are employed. Most of the cultivation is done by Mexican laborers or tenants, who cling to the old systems. Thus on most of the ditches the distribution of the water is by the Spanish method of days and hours, each holder of a water right having the use of the ditch in his turn.

The methods of applying the water are usually copied from those of the Mexicans, which consist of flooding the crops by means of little embankments or ridges of earth from 6 inches to a foot in height, so arranged as to convert the fields into checks of a size often absurdly diminutive. This system of watering has, indeed, been very largely modified by most of the American irrigators, so as to facilitate the use of machine tools in handling the crop; but the water is still wastefully used. It is to be hoped that in the present general development of irrigation more progressive methods will be inaugurated for both the distribution and the application of the water.

The early history of irrigation in Texas is hidden in the unwritten annals of the past. Several of the valleys of the Trans-Pecos country show signs of having once supported a teeming population. The lines of their irrigation canals can yet be traced for miles, while arrowheads, stone implements for grinding corn, and other relics can be found in considerable quantities. It must, however, be left to the

archæologist to determine who these aboriginal irrigators were and the probable antiquity of their work. The Pueblo Indians say that these ditches were made by the Yuma Indians, who were driven gradually westward by the Comanches and Apaches, finally settling in their present home on the Colorado River. On the Rio Grande below El Paso are several ditches, which are probably the oldest now in use in the United States. They were built by the Pueblo Indians, who, according to their traditions, migrated to this place from New Mexico at a very early date, certainly before the advent of the Spaniards under Coronado. This explorer mentions finding well-established systems of irrigation among the Indians in this vicinity in 1540, when he passed on his expedition northward. The old Spanish mission ditches around San Antonio, mentioned on later pages, are also worthy of note as among the oldest in the United States.

RETARDATION OF DEVELOPMENT.

Taking into consideration the climatic conditions and the object lesson furnished by the old ditches, it is somewhat remarkable that irrigation has not been more generally developed in Texas. The causes for the slow growth of this method of agriculture in the State as a whole are found in the persistent attempts of the settlers to extend methods of farming applicable in the humid East, and in the existing laws modeled on those of the well-watered region. There has been in Texas, as well as throughout the whole of the Great Plains region of the United States, a belief, founded upon hope and the representations of interested land agents, that the rainfall would increase as settlement progressed and tracts were brought under cultivation. In the subhumid region the annual fluctuations of water supply are always relatively large, but no permanent increase is shown by official records. The average distribution of rainfall in the western part of the State is favorable for agriculture, 19 per cent of it coming in the spring and 36 per cent in the summer, but in spite of this the crops are often either a total or a partial failure. In the country near the arid line this is the case about three years out of every four, because of the fact that a drought almost invariably occurs during the growing season, rendering useless all of the rain that falls afterwards.

Another cause of delay in irrigation development has inhered in the customs of the people. Their chief interests have been in cattle, and the results of so many years of nothing but stock raising have left them with neither the knowledge nor the inclination for the laborious occupation of the farmer.

But the principal bar to the spread of the industry has been the unsatisfactory condition of the laws relating to it. So long as the common-law doctrine of riparian rights was recognized as the only one having any force in the State, irrigation on a large scale was out of the question. At common law the riparian proprietor is entitled

to have the water flow through his land in quanity and quality as it was wont to do when he acquired the title thereto. There have been several instances in the past where progressive men who wished to use the water from some stream on their lands were prevented by actions brought or threatened for infringement of the riparian rights of the owners of the property lower down.

In 1875 and in 1888 laws were passed by the legislature for the encouragement of irrigation enterprises, but in both cases they proved inadequate. In 1895 the twenty-fourth legislature passed a new law regulating "the aquisition and use of water for irrigation, mining, milling, the construction of waterworks for cities and towns, and for stock raising." This law applies only to those portions of the State in which "by reason of the insufficient rainfall, or by reason of the irregularity of the rainfall, irrigation is beneficial for agricultural purposes." By this law the unappropriated waters of the above-mentioned portions of the State are declared to be public property, and provision is made for the appropriation of the same by private persons or corporations for the uses mentioned above. The riparian rights of a person owning property along such waters are recognized to the extent that the waters can not be diverted to his prejudice without his consent, or without condemnation proceedings carried on in a manner similar to those used in obtaining land for public purposes. The appropriator first in time is first in right. The law provides ample means for certifying to the appropriation and for regulating and protecting the corporations which may be organized for the purpose of using the waters thrown open to use by it. This middle course, in regard to the doctrine of riparian rights, is that adopted in California, Washington, and Oregon, and seems to have been successful in those States.

In 1897 there was passed by the twenty-fifth legislature a joint resolution to amend the constitution of the State by adding thereto a section which provides for the formation of irrigation districts without regard to county lines. Under the terms of this such districts could only be formed west of a line drawn through the State in a general north-south direction at about the eastern boundary of what is here described as the semiarid region. This amendment proposed that irrigation districts should be bodies corporate and have all of the rights and liabilities of ordinary irrigation corporations. They might issue bonds to cover cost of construction of their irrigation works, subject to the same restrictions as county and city bonds. The indebtedness for the construction of irrigation works in these districts could be created only by a vote of the majority of the landowners resident in the district and having lands susceptible of irrigation by the proposed works. The proposed amendment was submitted to a vote of the people at a special election on August 3, 1897, but was rejected by a heavy majority.

THE USE OF WATER.

The "duty of water" is the term used to express the relation between the quantity of water used in irrigation and the area upon which it is employed. The present duty of water in Texas can not be ascertained with the data in hand, but is in most cases very low. The duty assumed by most of the projectors of new irrigating enterprises is 100 acres to the second-foot. This, in the semiarid section at least, ought to prove sufficient, for by the time the amount of land under irrigation from each canal reaches the maximum the people will have learned how to use the water more economically than at first, and the land will not require so much. A careful estimate of the amount of land under irrigation in Mexico, just across the international border at Eagle Pass, gives a duty of 137 acres to the second-foot. There the crops are mainly corn and cotton, the latter needing very little water.

The investigations upon which this discussion is based revealed the fact that there are in the State not only a great variety of gravity systems of supplying water but also all kinds of pumping devices operated by steam or gasoline engines and by water wheels or windmills. The latter are of more importance than the data obtained would seem to indicate. Throughout the arid and semiarid regions nearly every residence has its windmill to pump water for domestic uses, the surplus of which is often used to irrigate a few vegetables or fruits around the house. Although a small area is watered by each mill, yet the aggregate must be considerable. Data were obtained from the few plants constructed for irrigation use only, which will give an idea of the comparative merits of windmills as a source of irrigation. The least cost of a windmill-irrigation plant was found to be a little over $16 for each acre irrigated, the largest area watered by one wheel being 30 acres. This is in the humid portion of the State. In the arid portion half that amount is all that can be supplied. The average cost is about $47 for each acre irrigated, and the area commanded by each wheel amounts to only about 7 acres.

The number of acres irrigated from each steam or pumping plant varies from 5 to 1,000. The cost of these irrigation plants ranges from $15 to $50 for each acre irrigated. The efficiency of most of the pumping plants could and should be very largely increased. There is a great lack of experience shown in the management of many of them, and consequently they have not been operated at anything like their full capacity or made to pay a reasonable dividend on the money invested. Few of them have reservoirs into which to pump the water; thus they can be used only while the actual irrigation is going on, whereas to be operated economically they should be run day and night, at least during the irrigating season. There are

a number of plants in the State with a capacity of as much as 2,500 gallons of water per minute. Such a plant, if worked to its full capacity, will give a stream equal to 5.57 second-feet. Allowing one-third for loss by seepage and evaporation, there is left 3.7 second-feet. The usual duty of water is estimated at 100 acres to the second-foot, but in new irrigation districts it very often amounts to only half as much. Even with this low estimate there should be more than 180 acres irrigated from the plant. Such a plant, it is estimated by H. M. Wilson, can be erected for $5,000; this will give a cost of $28 per acre irrigated.

For estimating the quantity of water used in irrigation, various units of measurement are employed. For bodies of standing water the cubic foot, or, where that is too small a unit, the "acre-foot" is used. The latter is the quantity of water that will cover an acre of ground 1 foot deep, or 43,560 cubic feet. The gallon is also very largely used for stationary bodies of water and for pumping plants, especially those for municipal supply. In considering flowing water some unit must be used which expresses the capacity of the stream in a given period of time. That most commonly used is the second-foot, or the number of cubic feet of water which flow by in a second of time. The "miners' inch," so generally quoted in California and Colorado, is not used in this State. In the following table are given some convertible units of measurement:

Units of measurement used in irrigation, with equivalents.

1 cubic foot=0.0283 cubic meter=7.48 gallons.
1 cubic foot of water weighs 62.4 pounds.
1 second-foot=449 gallons per minute=26,930 gallons per hour.
1 second-foot=50 California miners' inches.
1 second-foot=40 Arizona miners' inches.
1 second-foot for one day=1.9835 acre-feet.
1 second-foot for one day=646,317 gallons.
1 second-foot of water falling 10 feet gives 1.135 horsepower.
1 horsepower is given by 1 second-foot of water falling 8.8 feet.
1 gallon of water=231 cubic inches=0.13368 cubic foot, and weighs 8.34 pounds.
1,000 gallons per hour=0.037 second-foot.
1,000,000 gallons=3.07 acre-feet.
1,000,000 gallons per twenty-four hours=1.55 second-feet.
1 acre=43,560 square feet, or nearly 209 feet square.
1 acre-foot=325,850 gallons.

DISTRIBUTION OF RAINFALL.

The most important element of climate in its relation to the present discussion is precipitation. In Texas the rainfall is greatest in the eastern portion of the State and decreases steadily toward the west. This decrease is at the rate of about 4 inches every 60 miles, being about 50 inches in the extreme east and 9 inches at El Paso. The

isohyetals, or lines of equal precipitation, run through the State in a general north-south direction, as shown by the map, fig. 1.

The customary definition of "arid region" is one having less than 20 inches of mean annual rainfall. This, however, is not sufficiently complete, for it does not take into account the distribution of the rain throughout the year. In certain parts of the country, where the greater portion of the precipitation occurs during the crop season, wheat and other cereals are successfully raised when the rainfall is far less than 20 inches; while in other parts of the United States, as,

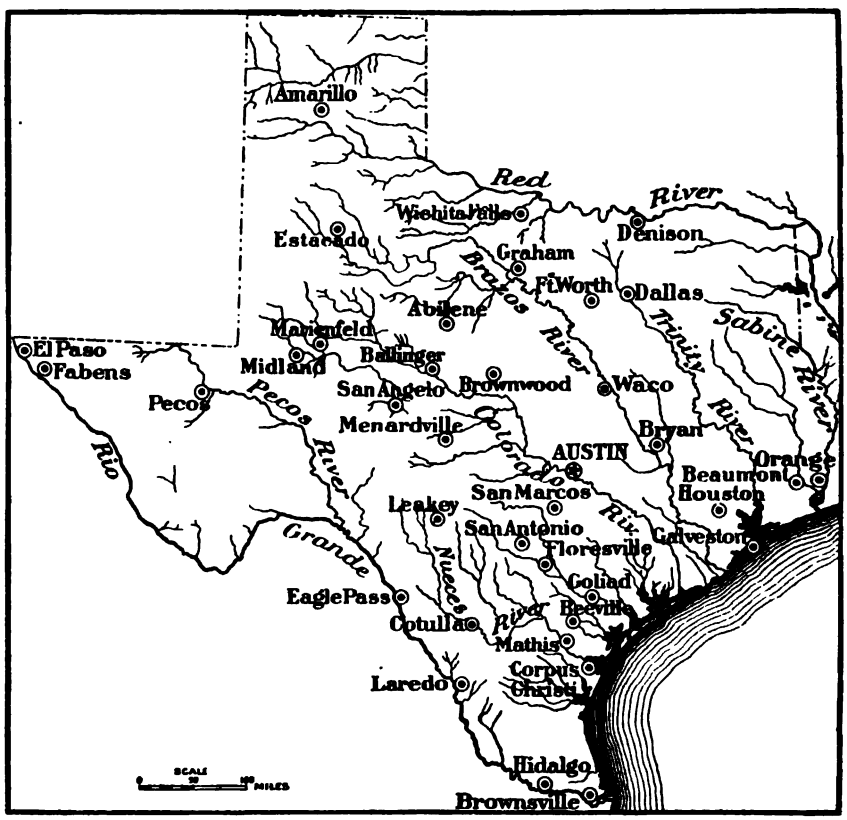


FIG. 1.—Index map of Texas.

for example, near the Pacific coast, where the greatest precipitation occurs during the winter months and the summers are practically rainless, irrigation is necessary during a part, at least, of the crop season. Thus the distribution by months is almost as important an element as the total quantity occurring during the year.

The accompanying diagram, fig. 2, shows the quantity and average distribution of rainfall by months at a number of selected stations fairly typical of the State as a whole. The first of these is Galveston, on the coast, in the eastern part of the State. Here the average

rainfall for twenty-seven years is 49.6 inches. As shown by the diagram, the months of heaviest precipitation are September and August, but in every month except February an average of over 3 inches of rain has fallen. This is fairly typical of the distribution of rainfall along the Gulf coast. The diagram next above this is for Austin, where the average rainfall for thirty-nine years is 33.4 inches. Here, also, there is an excess of precipitation in September, and a second maximum in May. Relatively to these months, June, July, and August are somewhat dry; but in every month throughout the year there has fallen an average of over 2 inches of rain.

The next diagram in fig. 2 above that for Austin is that for Fort Clark or Brackettville. This is constructed from the average for twenty-nine years. The mean annual rainfall is 22.7 inches. Fort Clark is remote from the coast, and the distribution of its rainfall, though somewhat similar to that at Austin, having maxima in September and May, shows reduction in quantity, especially during the winter months. Next above the diagram for Fort Clark is that for Fort Elliott, situated far up in the Panhandle of Texas, near the Oklahoma line. Here the quantity and distribution are fairly typical of the Great Plains area. The diagram is derived from the mean of observations extending over eleven years and giving an annual average of 23.2 inches. The month of greatest rainfall is May, September being below the average. The rainy season may be said to extend from April to August.

In the upper part of fig. 2 are two diagrams illustrating the typical distribution of rain in Trans-Pecos Texas. This has been named by General Greely the Mexican type of rainfall.[1] In these, particularly in the diagram for Fort Davis, obtained from twenty-six years' observations, the rainfall is seen to increase regularly from February to August and then to decrease rapidly to the end of the year. The greater part of the precipitation occurs during

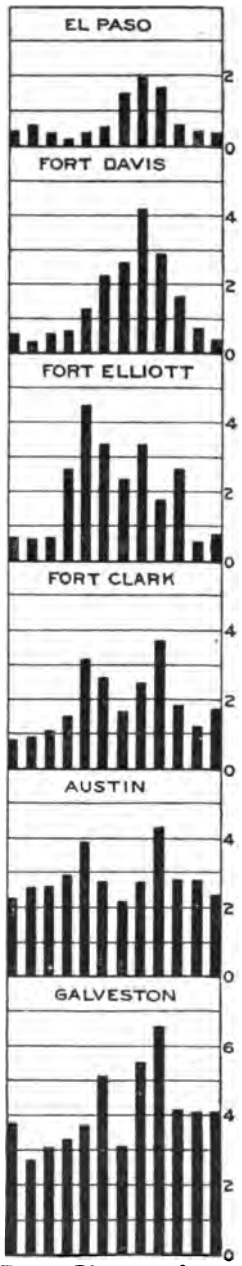


FIG. 2.—Diagrams of mean monthly rainfall at six stations.

[1] Nat. Geog. Mag., Vol. V, 1893, p. 51.

June, July, August, and September, at the time when most needed by many crops. The diagram for El Paso, from thirty-six years' averages, shows a relatively uniform but small precipitation throughout the year, with the exception of the months of July, August, and September.

CLIMATIC AND GEOGRAPHIC DIVISIONS.

In order to discuss the present condition and development of irrigation in Texas it is essential to pursue some systematic order of arrangement based upon climatic or geographic factors. The simplest arrangement is that of taking first the humid region, or that having 40 inches or over of rainfall; next the subhumid, with from 30 to 40 inches; then the semiarid, with from 20 to 30 inches of rain; and last the more arid portions, having less than 20 inches of annual precipitation, this being in the western part of the State, and including the Panhandle and Trans-Pecos regions. The greater part of the irrigation works are, however, in the southern half of the State, or near the coast, and these divisions, especially those of subhumid and semiarid, extending, as they do, in a north-south direction, though simple, do not afford a wholly satisfactory grouping. In the central part of the State the irrigation works are small, and there is no essential difference between those in the more humid and those in the semiarid areas. In fact, the actual amount of annual precipitation has less to do with the necessity for artificially applying water than the local conditions of soil and character of crops.

From the above-mentioned conditions it has been found desirable to adopt a somewhat arbitrary classification, based partly upon the distribution of rainfall and partly upon geographic position. In the following pages, therefore, a description will first be given of the irrigation plants in the humid area near the coast, particularly those lying within 50 miles or more of Galveston. Next in order are the small irrigation projects scattered about the center of the State from the humid areas east of Brazos River westward nearly to the borders of the arid region and southward to the vicinity of Austin and San Marcos. The third division is taken to include the old irrigation works at San Antonio, with small irrigation projects found at intervals down to the coast. Next in order to these are the irrigation works planned or constructed along the Nueces River and the lower Rio Grande. The fifth division to be considered is that of the Llano Estacado and adjacent areas, including the greater part of Panhandle Texas; then the lands watered by the Pecos River, and finally the irrigation works in Trans-Pecos Texas, extending to the extreme westerly end at El Paso.

DESCRIPTION OF IRRIGATION WORKS AND PROJECTS.

EASTERN GULF COAST REGION.

The humid part of the State may be considered as that having a mean annual precipitation of 40 inches or more. This comprises the greater part of the State east of the city of Dallas and of the lower Brazos River. The rainfall over this area is usually abundant, and irrigation in the northern and central portions of this humid region will not probably become of any considerable importance, but in the southern end, along the coast, there exist large tracts of land adapted to rice growing, and the greater portion of this will probably be used for this purpose.

This land is mostly a flat prairie, locally called swale land, covered with a coarse growth of grass and having such a gentle slope toward the sea as to be but little removed from a marsh during a large part of the year. It extends inland for several miles and is cut by numerous bayous, in which the tides from the Gulf ebb and flow and the waters gradually become brackish as they near the Gulf. Most of the rice farms lie along these bayous, and from them the principal supply of water is derived. The farms are so located as to insure a supply of fresh water. The soil along the bayous is much richer than the prairies and yields heavier crops.

The manner of cultivating and irrigating is very different from the South Carolina system, where the water is held by artificial storage reservoirs or raised above the level of the fields by the action of the ocean tides, which back up the flow of the rivers at each tide to a height sufficient to reach the fields. In this part of Texas storage reservoirs are used in only a few cases, most of the fields being supplied by pumps placed on the banks of the bayous and operated by steam power. The land is laid off in much the same way as on the eastern plantations. The work in this State is newer and therefore rougher, but the main features are the same. The fields are surrounded by low levees to hold the water on the land, and are ditched to permit drainage at the lowest point.

Nearly all of the land planted with rice is irrigated, as those who have attempted to grow it without irrigation have lost their crops two years out of five and made only very short crops during the other three years. As previously stated, the water is supplied to the fields by pumps run by steam power, rotary pumps of the Menge pattern being most frequently used. These are operated by engines of from 10 to 70 horsepower or more, and have a pumping capacity of from 1,500 to 8,000 gallons per minute, or from 3.34 to 17.82 second-feet. The lift varies from 9 to 12 feet, and the pumps are run night and day during the irrigating season, which lasts from sixty to ninety days, thus delivering from 400 to 3,000 acre-feet of water. For the prairie farms the water is carried in canals, either on the surface or

excavated but little below it and confined by levee walls on each side, for a distance sometimes of 1½ miles.

The area in rice is increasing rapidly. One planter, Mr. J. E. Broussard, of Beaumont, has 750 acres this season (1897), whereas last season he had but 250 acres. He estimates that the total area watered from Taylors Bayou alone, in Jefferson County, in 1897, was 8,500 acres. From his statements the following facts were derived: Planting of early rice is begun in March, from about the 15th to the 25th, if ground and weather are suitable, and continued until the 1st of June. Many persons plant as late as the 15th of June, but this is probably too late to make a good crop. As soon as the rice is up to a height of 6 or 8 inches, if the ground becomes too dry for it to grow well, the usual practice is to give it a good soaking, but not to hold the water very deep upon it the first time. As soon as the rice becomes well rooted, the land is flooded and the attempt is made to keep it in this condition until the rice is ready for harvest. Most farmers turn the water off about two weeks before harvesting, although there is considerable difference in this matter. The size of field inclosed under each set of levees depends altogether on the lay of the land; if very level, there may be as much as 50 acres in one "cut," but where the land has much fall the average piece under one set of levees will be about 5 to 8 acres. The lands are so level that when the water is from 4 to 6 inches deep over the lowest part it will wet the highest portions. The depth of flooding rice in this section is about 5 or 6 inches; some farmers prefer deeper water, while others do not care for so much. Experience has shown that when water is held very deep on rice all the time the quality of the grain is not so good; it is sufficiently heavy but is somewhat "chalky." There are several farms that have from 500 to 1,000 acres under cultivation in rice. The average yield is reported to be 40 bushels to the acre of rough rice, or 10 barrels of clean. One hundred pounds of rough grain will make about 72 pounds of clean rice.

Mr. F. H. Catron, of Orange, has been one of the most successful planters. He has been irrigating since 1891 with a Menge pump, operated by a 50-horsepower steam engine, pumping from a bayou into a surface ditch 1 mile long and 20 feet wide, the lift being about 8 feet. The total cost of the canal levees and ditches was $5,000, and the engine and other parts of the pumping plant cost $1,500. The pumping capacity is 5,000 gallons per minute, or 11.14 second-feet. In 1896 he irrigated 500 acres of rice.

Irrigation of orchards and gardens is resorted to in this humid region, particularly in the vicinity of Galveston and Houston. This is due largely to the fact that artesian water can be had, and the land is so nearly level that water can be readily applied. In spite of the abundant rainfall, experience has shown that fruit and garden crops are greatly improved in quantity and quality by the application of

moisture during a portion of the year, particularly at times of summer drought. Operations on a considerable scale have not been attempted, but many small gardens are being watered. Nearly all of this land requires drainage, and this is especially the case when irrigation is introduced. The prairie land in this region is not notably rich, but it is easily worked, and as a rule ground water is near the surface.

The source of water for the city of Galveston is at the suburban town of Alta Loma, 18 miles distant from Galveston. Here are 27 wells 7 inches in diameter and 3 wells 9 inches in diameter, from 750 to 850 feet deep, all located in a direct north-south line, 300 to 750 feet apart, making a total distance from end to end of 16,350 feet. The wells, at 2 feet above the ground, showed a static pressure of from 5 to 7 pounds per square inch. Water is derived from several horizons, and the combined flow is 12 million gallons per day, or 18.60 second-feet. The pressure is sufficient to deliver 5 million gallons daily, or 7.73 second-feet, at the city of Galveston, 18 miles away, through a 30-inch pipe having a fall of 1 foot to the mile. A portion of this 30-inch pipe is depressed about 10 feet for a distance of 2½ miles, from the mainland to the island, under West Galveston Bay. These wells have been flowing for three years. The cost for the installation of the entire plant was $790,000. Analysis shows that the water is usually pure, and the people of Galveston are highly gratified in having a water supply of such excellence.[1]

The water-bearing strata underlying this portion of Texas are so uniform in character that contractors do not hesitate to guarantee a flow of from 25,000 to 50,000 gallons daily, or 0.04 to 0.08 second-feet, for a specified size of well at any point in or near Galveston County. There are 5 artesian wells at and about Clear Creek, 1 at Shell Siding, 10 in the vicinity of Dickinson, 2 at North Galveston, 1 at Texas City, several at Hitchcock, 2 or 3 at Alta Loma in addition to those already mentioned, and 2 at Arcadia, making a total of not fewer than 55 for the county. In some localities sufficient flow for smaller wells is obtained at a depth of 490 feet, though occasionally the extreme depth of from 1,000 to 1,100 feet is required.

Water for irrigation is also provided by using windmills. There is a stratum of water-bearing sand at a depth of from 30 to 60 feet which furnishes an abundant supply for irrigation by the smaller land holders and market gardeners. For example, Mr. H. Sampson, an orchardist near Alvin, has a surface well 12 inches in diameter and 36 feet deep, in which he put an 8-inch tubing. He asserts that from 15,000 to 30,000 gallons can be pumped from it daily by a windmill of sufficient size. Within the town limits of Alvin, Mr. W. H. Nash has a similar well which he states has never been pumped dry by a 10-foot windmill. He irrigates all the berry and garden crops which he

[1] Engineering News, Vol. XXXIX, No. 9, March 3, 1898.

thinks it advisable to grow in between the trees of a 10-acre bearing pear orchard.

This will convey a brief but positively reliable idea of the underlying water supply of the Texas coast for irrigation purposes. It remains to add a word concerning the use of water for irrigation purposes in this section. The structure of the soil is somewhat peculiar in that it is naturally subirrigated; that is to say, there is plenty of water within from 7 to 15 feet of the surface. An ordinary barnyard well does not exceed in most instances 10 to 12 feet in depth. Almost all the varieties of trees planted in the orchards here readily send their roots to this and greater depths, and hence for commercial orchards irrigation is not essential. This is especially true if timely, judicious, and frequent cultivation be given. With the berry grower and market gardener the conditions are different. His crops must be made within a specified period to obtain the best results and greatest returns. To accomplish this it is essential that a good supply of water be at command to force the crops when conditions of great heat and drought develop. At the same time it should be noted that perhaps 90 per cent of the berry growers and gardeners have not yet provided irrigation works, and they have been, in a measure, doing business with a small but very uncertain margin of profit. They have hoped each year that it would not be necessary for them to irrigate. Two successive seasons of drought, however, have induced them to prepare to avail themselves of the ample supply of water. Within two years from this time probably the greater part of the most intelligent berry and truck growers will be fully equipped with an irrigation plant of some description.

The advantages of having irrigation facilities were abundantly illustrated in 1896. Those who had such equipments were not only selling more products at the same time that their neighbors were offering theirs, but were selling long and profitably after their less fortunate competitors could not produce sufficiently to make an attempt at marketing advisable. This is especially noteworthy in the case of the strawberry growers in the coast country.

CENTRAL TEXAS.

This second division has been arbitrarily drawn to include the irrigation plants, mostly small in size, situated within the central part of Texas, from about the vicinity of Brazos River westerly to the edge of the arid region, and from the vicinity of Austin, on the south, northerly through the State. This area falls between the lines of mean annual precipitation of 20 and 40 inches, and thus includes the tract of country having sufficient rainfall to raise crops in ordinary seasons. The precipitation is fairly uniformly distributed by months, as shown by the diagram of mean monthly rainfall at Austin in fig. 2 (p. 23). The black, waxy soil which covers a considerable portion of

this district is retentive of moisture and resists droughts, as does the land along the Brazos and Colorado river bottoms, located mainly within this area. The region to the south and southeast of Austin, although having the same mean annual precipitation, has not been included in this division, because the rapidly increasing temperature toward the Gulf, as well as the different character of the soil, renders irrigation somewhat more essential and its development is more nearly comparable to that of the arid region to the west.

In this central portion of Texas, where crops are raised successfully each year, irrigation is not felt to be a necessity except by truck farmers and nursery men, and many of these have introduced it in a somewhat experimental way. The results, however, demonstrate its value, and this method of cultivating the soil is being extended. Water is usually obtained from a well or small storage reservoir, and pumped by means of a windmill, or occasionally by a small steam engine.

The most easterly of the irrigation works in this section are those at Mexia, near the head of Navasota River, a tributary of the Brazos, and near Bryan, on Brazos River, at the State Agricultural and Mechanical College. At this latter point storm waters are impounded in a reservoir formed by building an earthen dam 10 feet in height and 100 feet long across a small draw. This covers about 1 acre, and from it so far about 7 acres have been regularly irrigated, the crops watered being garden truck and alfalfa. In addition to the storm waters, the reservoir is so situated as to receive the waste water from the college ice factory and from the natatorium when necessary, but as this water, coming from an artesian well, carries in solution considerable mineral matter, it is not allowed to enter the reservoir to any considerable extent.

At Mexia, in Limestone County, J. W. Stubenrauch has been very successful in the use of a small irrigation plant for fruits and vegetables. This consists of a dam across a ravine, catching the storm waters and forming a tank covering about an acre of ground. From this the water is lifted to a height of 25 feet by an 8-foot windmill into an earthen reservoir 50 feet long and 100 feet wide. This reservoir is now being enlarged to have double the present capacity. The total cost of the system was $300, including 700 feet of piping; 7 acres have been irrigated, but it is estimated that 15 acres could be watered. Mr. Stubenrauch is also putting in another system with a reservoir covering an acre of ground, the dam having a height of 5 feet above the outlet pipe, for filling which he will use a 12-foot wheel. This he expects will enable him to irrigate 30 acres at one time. He states that the total cost, including 600 feet of 2½-inch pipe for discharging the water into the reservoir, was $485. He pumps from a storage tank made by damming a big ravine.

In the northern end of this district—that is, north of the Colorado

River—irrigation is little practiced. There is a well-developed plan to irrigate a large tract of exceptionally fertile land in the Wichita River Valley. The storm flow of this river is to be stored at a favorable site about midway of its course. The catchment area above this storage basin will be about 1½ million acres. The area to be irrigated is about 270,000 acres.

Careful flood-flow determinations indicate that the supply is largely in excess of requirements. The region has a rainfall of about 28 inches, which it is necessary merely to supplement. That is, the duty of water here will be comparatively large. In fact, the greater part of the area is at present utilized as farm land. But, though the lands are rich and easily tillable and the average yield is considerable, there is yet a disastrous variability of yield on account of droughts. Therefore, relating to a subhumid rather than to an arid region, the project will have this advantage over irrigation undertakings in the

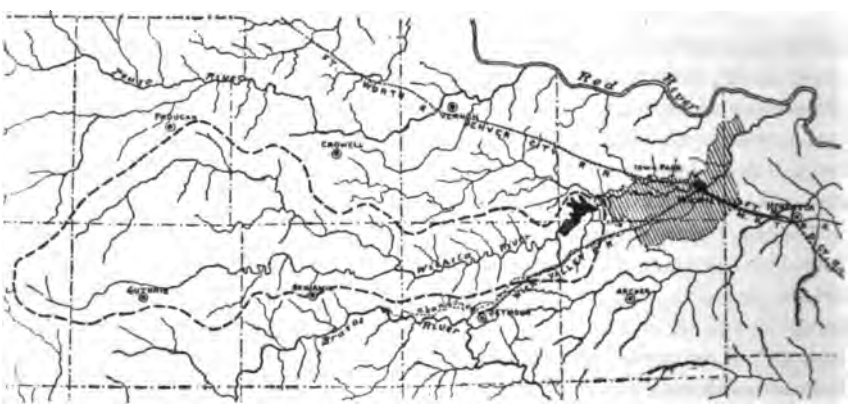


FIG. 8.—Map of drainage basin of Wichita River.

arid lands proper, that the amount of water needed for abundant crop yield is comparatively small. The plan, which has been developed fully, is based upon careful and elaborate engineering work. Before the present reservoir site was chosen, other possible sites, along the Pease River to the north and the Brazos River to the south, were examined with a view to diversion of these streams to the same lands. The present selection appears to be an exceptionally fortunate one. The depth to bed rock at the dam site is slight and the river valley here is constricted to a canyon.

The dam is to be of earth, 80 feet high, designed to hold water to a depth of 70 feet. Both spillway and outlet are to one side, well away from the dam—the spillway over bed rock, the outlet through a tunnel in bed rock. The capacity of the reservoir will be about 12,000 million cubic feet, or about 275,000 acre-feet. There will be two canals, designed to irrigate both slopes of the Wichita Valley. At their head these canals will have a width at bottom of 40 feet, a depth

of 8 feet, and a grade of 1 foot to 5,000 feet. The total cost is estimated at a little over $1,000,000.

Careful determinations of flood flow made by the company's engineer, Murray Harris, indicate that the supply is much more than ample. They are as follows:

	Acre-feet.
During the first week in January, 1897, about	59,687
From March 28 to April 4, 1897, about	98,714
From April 25 to April 29, 1897, about	174,472
From April 29 to May 15, 1897	330,579
Total	663,452

Farther south, near Brazos River, in Young County, not far from Graham, are reported two small gardens irrigated by windmills, such as are found scattered all through the semiarid region.

The Lytle Water Company, in 1897, began to build a dam across Lytle Creek at Abilene, in Taylor County, the main object being to furnish good water to the town, but it is also expected to irrigate 300 acres by a canal 1½ miles long. The dam is of earth, riprapped with rock on the inner slope and sodded on the outer. It is 800 feet long, raises the water 15 feet, and has a masonry spillway of 300 feet. The total cost of the plant will be about $25,000. The reservoir formed by the dam will cover 120 acres and have a capacity of 300 million gallons, or 920 acre-feet.

On the ranch of Hugh Lewis, 8 miles north of Ballinger, in Runnels County, is a stone dam built in 1896 across a small creek which originates in a spring a short distance above. The dam is 80 feet long, raises the water 6 feet, and supplies a ditch some 200 yards in length. Ten acres in fruit and vegetables were irrigated in 1896, but at least 50 acres could be covered. The total cost was from $150 to $200.

In Tom Green and Irion counties the water facilities furnished by the Concho River and its numerous branches and tributaries are among the finest to be found anywhere. These have only been partially used by individuals and small companies in separate systems, making the cost of maintenance much greater than if consolidated. Nevertheless, they have been fairly successful, and have certainly reduced the cost of living in that section, making foodstuffs, especially vegetables, much cheaper and more abundant. There are ten of these plants reported in those two counties; three on the South Concho, one on the Main Concho, and two each on the North Concho, Spring Creek, and Dove Creek. The total area irrigated is 3,200 acres, 2,000 being in Tom Green County and 1,200 in Irion County.

The plants of C. B. Metcalfe, of San Angelo, and J. J. Glenn, of Water Valley, may be taken as types of the systems in vogue. Mr. Metcalfe's canal takes its water from the east bank of the South Concho River 12 miles south of San Angelo. It is 4 miles long, with

an average top width of 12 feet, bottom width 8 feet, and depth of water 1.5 feet. It was begun in 1887 and the first mile was completed the next year, but it was not entirely completed until 1896. It takes its water by means of a brush-and-stone dam 200 feet long and 7 feet high, which extends across the river and cost about $500. The main ditch cost $500 to the mile, and the laterals, of which there are three, cost $250 to the mile, making a total cost, with incidentals, of $7 to each of the 470 acres now irrigated. The repairs, which are maintained by the tenants, may be estimated as amounting in labor to 75 cents per acre. The crops irrigated in 1896 were: Johnson grass, 40 acres; cotton, 120 acres; corn, oats, wheat, truck, etc., 220 acres; total, 380 acres.

The ditch of J. J. Glenn is located on the North Concho 1½ miles west of Water Valley, and is 3 miles long, 8 feet wide on top, 4 feet wide on bottom, and 2½ feet deep. It was first used in 1886, and is supplied with water by a rock dam across the river, 100 feet long, with an average height of 8 feet. The total cost of the system was $3,500, and it commands 350 acres, of which 250 have been irrigated, two-thirds in cotton and the remainder in the different sorghums and oats.

The most successful field crops in this region are oats and cotton, the former producing from 30 to 90 bushels with great certainty, and the latter usually 1 and sometimes 1½ bales to the acre. Corn is a poor crop, by reason of the dry winds, but sweet potatoes, melons, and celery do very well, especially the last named.

In Sterling County there are two systems on Concho River, only one of which has been reported in full. It is located 5 miles from Sterling City and is owned by the McGee Irrigation Company. The main ditch is 2 miles long, has a top width of 6 feet, is 4 feet wide at the bottom, and carries about 1 foot of water. It was begun in 1892 and first used in 1894. The water is raised by a loose-rock dam, 125 feet long and 6 feet high, built across the river. The total cost was $1,500, and it commands 250 acres, only 75 of which are really irrigated. The principal crops, in the order of their importance, were cotton, corn, sorghum, oats, sweet potatoes, alfalfa, and vegetables. Repairs are maintained by each stockholder doing his share of the work on the ditch.

At Brownwood, in Brown County, about 120 miles east of the above works, considerable interest has been taken in irrigation during the last few years, there being a large area well located for irrigation on a considerable scale. This scheme was abandoned for lack of capital to complete it. Meanwhile several steam pumping plants have been erected for irrigating smaller areas. The most important is that of the Swinden Pecan Orchard Company. This consists of a centrifugal pump operated by an 80-horsepower engine and pumping 3,000 gallons per minute, or 6.84 second-feet. The water is carried by a flume

4,000 feet long to a reservoir formed by building an earthen dam 4,000 feet long and with a height varying from 2 to 15 feet. The dam is at the foot of gently sloping land, and forms a triangular reservoir covering 55 acres. The reservoir is designed to irrigate the 400 acres of level land lying between it and Pecan Bayou, from which the water is pumped to fill it. A small stream is also dammed and turned into the reservoir. The 400 acres commanded by the reservoir are planted in pecan trees, making the largest orchard of this kind in the world. The irrigation plant was put in mainly to enable the owners to practice truck farming and small fruit growing between the rows of trees while waiting for the latter to mature. The soil is a rich black and chocolate loam. The great mistake that has been made in this plant is in having the reservoir so large and shallow. Evaporation and seepage are in this way so increased as to become a serious source of loss.

Immediately east of this, in Mills County, are several pumping plants on Colorado River. That of J. B. Baker, 11 miles southwest of Goldthwaite, was completed in 1896, and consists of a 32-horsepower boiler operating a Worthington pump. The plant cost $2,000, and the expense of operating it is about $7 a day of twelve hours. It has a capacity of 1,220 gallons per minute, or 2.72 second-feet, and commands 80 acres, 75 of which were irrigated. The crops raised were corn, cotton, and oats. J. D. Willis, of Ratler, has attached pumps with a capacity of 50 gallons per minute, or 0.11 second-foot, to the shafting of his gin and grist mill, irrigating 5 acres in fruits and vegetables. The power is furnished by a turbine under a 5-foot head of water from a dam 300 feet long across Colorado River. At Regency, G. W. Alldridge, with a 20-horsepower engine, pumps 450 gallons per minute, or 1 second-foot, and reports that he can water about 5 acres per day, which would give 50 to 75 acres under command of his pump. None of these men use reservoirs.

On the south side of Colorado River, in San Saba County, J. H. Lindsey owns a steam pumping plant on the river, 20 miles north of San Saba. It consists of a 30-horsepower engine and a pump with a capacity of 840 gallons per minute, or 1.87 second-feet. The plant cost $2,000 and is worked eleven hours a day at an expense of $3, irrigating 40 acres in corn and cotton. There are also several small areas irrigated in this county from the numerous springs which issue from among the hills. The total amount of these is 250 acres. Farther down the river, in Burnet County, the only irrigation reported is one windmill irrigating a garden 50 feet long and 150 broad, and also 1¾ acres watered by a spring and reservoir. Both are very successful.

At the head of San Saba River, in Schleicher County, William L. Black has been irrigating since 1894 with a plant consisting of a 6-horsepower engine, pumping 580 gallons per minute, or 1.29 second-feet, and a 6-foot overshot wheel with a capacity of 167 gallons per

minute, or 0.37 second-foot. The latter is run day and night, no reservoir being provided, and the total area irrigated is 50 acres, in corn, potatoes, and sorghum. With his water wheel he uses four 10-inch cylinders worked horizontally, and with the engine a link-belt box elevator, which gives satisfaction. Farther east, in Menard County, on San Saba River, is a pumping plant owned by Emile Vanderstucken and consisting of an 18-horsepower steam engine operating by a belt a Menge centrifugal pump with a capacity of 1,167 gallons per minute, or 2.60 second-feet. The total cost of the plant was $1,500. No reservoir is used, the water being carried in a flume to the highest point on the land and distributed by ditches. On account of the abundance of rain in 1897 it was used but very little. In 1896 it was operated from March to September, irrigating 100 acres and making good crops, with practically no rain.

The following description relating to the condition of irrigation in the vicinity of Menardville is taken from a statement prepared by Mr. Robert S. Dod, of Brady, Texas, county surveyor of McCulloch County. This method of agriculture has been a great success in this vicinity, as is evident to anyone passing through the county examining the fields and conversing with the farmers. The system has not always been successful, but early failures were mainly the result of inexperience and arose from accidental and not from essential defects. Mistakes have been gradually remedied, and by well-directed energy and enterprise great improvements have been brought about, progress being still made toward even better methods.

On crossing San Saba River 5 miles below Menardville, the traveler enters upon the irrigated part of the narrow valley lying between the river and the low hills, and is impressed by the signs of energy and activity. The fences are good and in repair; the gates have two hinges and swing clear of the ground; the fields are clear of grubs and clean of weeds; the ditches are straight and well shaped and clean; the cotton as seen when visited stood 28 to 30 inches high all over the fields, of good color and as clean as possible. The corn was 10 feet high or over, and the dark green of its leaves was accounted for by the water running in the furrows at its roots. To the right was an orchard of peach trees filled with fruit, and beyond this a stubble field already plowed and harrowed, ready for reseeding for another harvest. Near this field stood the stacks, the proof of the success of that crop at least, yielding their stores of grain to the efforts of the busy crowd about the thrasher. The active movements of the men at work there and in the neighboring fields, and the rate at which the teams traveled carrying the grain to the barn and returning to the field, showed that the success apparent everywhere was due to systematic, well-directed effort—the kind of effort that men put forth when reasonably certain of the reward of their labor. Such animation men do not display when disappointment and failure year after year have sapped

their energy and made them cynically hopeless of success, when under "dry farming" they have degenerated into the almost brutish attitude of contentment with surroundings that could be improved and toleration of losses that might be avoided.

All the way from the river to Menardville the road passes through irrigated farms showing success in proportion to the amount of care and labor expended on them. The vegetable gardens, the orchards, the green lawns, and the flowers and vines around the houses make this valley the picture of contented prosperity. The farmers with whom conversation was had gave many facts applicable in contrasting their methods and results with those of the dry-land farmer. They raise from 1 to 2 bales of cotton per acre, the difference in yield depending largely on how much damage the worms do in a given season and how much rain falls in August. The drier this month the better the cotton crop. On new land with few worms and a dry August 2 bales would be expected. Their corn yields from 40 to 80 bushels per acre. One man suggested that a light rain or shower was needed when the pollen was ripe in order to obtain the best results. Oats yield from 50 to 80 bushels per acre. During the years from about 1888 to 1895 the farmers irrigating in Menard County were raising from 1 to 2 bales of cotton to the acre, 40 to 50 bushels of corn, and 80 or more of oats, while in contrast to this their neighbors without irrigation were working perhaps equally as hard, bringing together what little cane and fodder could be raised to save the stock from starving to death, and producing only enough marketable stuff to keep the interest on the mortgages paid up, and perhaps not even that.

These beneficial results are produced by a little water and a deal of hard work. The water rate is $2 per inch, and 1¼ inches will irrigate an acre of their land, so that $2.50 per acre and a little extra work make the difference between one-third of a bale of cotton and 2 bales; between no corn and 40 to 50 bushels; between 80 bushels of oats and a dead failure.

It has been proved by experience that one man can not give proper attention to more than 25 acres of this irrigated land. He will need help in cultivating if he plants corn and cotton, but could tend rather more land put in small grain. He will require for these crops a little over an inch of water per acre, and will need to turn the water on about every twenty days.

At Menardville corn and cotton are irrigated by running the water down the furrows between the rows from openings in the ditch. The amount of labor required for the operation and to make the water run properly depends upon the general level of the field and the care with which the furrows are laid off with regard to the slope. Small grain and fodder crops are laid off by throwing two furrows together, back to back, as a border, every 8 or 10 steps, to hold the water, and flooding the land between these borders. Some farmers use an Acme

harrow to finish off the land after planting, running it between the borders so that the small furrows left by it help in directing the flow of the water.

As to the amount of water required per acre, one man who irrigates 40 acres of land uses 40 inches of water, and occasionally needs a little more. On another farm they use 15 inches of water on 12 acres of garden truck. On the upper part of the ditch above town the water is measured and distributed by the inch; that is, if a man wants 20 inches of water, the gate opening on his ditch is set for a 20-inch flow and so remains through the season, giving him his 20-inch constant flow. From town down they use the water in rotation, as, owing to a mistake originally made in laying out the distributaries, the use of water above interferes with the flow below. So they alternate every seven days, those above using all the water that reaches them for that time, and then the lower owner having all the water for the next seven days; this farmer, having some 500 acres under irrigation, distributes the water over them as necessary.

The amount of water required for an acre of ground here is more than that needed for sandy fields. The soil at Menardville is a clayey loam containing a large proportion of lime. Both soils require the same amount of water for the first irrigation, but the sand packs and requires less at each succeeding irrigation, whereas it is claimed that the limy loam seems to rise instead of pack, and requires as much water for the later irrigation as for the first.

The ditch which supplies these farms is nearly 10 miles long. The dam is built across San Saba River some 4 miles above Menardville and returns to the river some 5 miles below the town. The charter was obtained by the Vaughan Agricultural and Improvement Company in 1874, and the ditch was built soon after. It is claimed that this company put $12,000 in the work. This was excessive, an extra expense being incurred by the refusal of right of way in one instance, forcing the company to make a cut 16 feet deep and several hundred feet long. Further, the methods of work were rude and costly. Wheelbarrows were used to move the dirt, and in the cut the dirt was thrown on staging and passed from man to man. There are 97 shares in the company, valued at $180 each. One year $1,200 was spent in improvement; another year $1,000 in the same way; but the ditch pays all running expenses, cost of improvements, and 10 per cent on the shares at the above quotations.

The grade of the ditch after construction was found to be irregular and unsuitable, so work has been done each year—cutting and filling, to reduce the slope above Los Mores flume to a nearly uniform grade of 30 inches to the mile. At the flume is a fall of 14 inches in 128 feet. At the point of the mountain where the ditch curves with the hill and runs through rock it is lessened in size and has a much steeper grade. The grade of 30 inches to the mile was established

experimentally, and satisfies as nearly as possible the necessity of avoiding silting on the one hand and erosion on the other. The ditch runs through coarse gravel part of the way, and there is a heavy loss from percolation.

The straightening of the ditch, reduction of the grade, and tightening of the dam have given an available flow of water sufficient to irrigate 2,000 acres of land, which is the amount estimated to be under irrigation from this ditch at the present time. This taxes the flow to its full capacity.

The dam is built of rough limestone quarried at the spot, averaging, where seen on the front of the dam, 2 by 3 feet by 10 inches, laid in courses without cement. The blocks are tied by bolts fastened to a log under the dam at the bottom and passing up through the dam and fastened at the top by taps to cross-ties lying along the top. The dam is slightly concave and is about 200 feet long and 5½ feet high at the middle of the front, with an irregular batter. It is 13½ feet wide on top at the center. It rests partly on rock, partly on gravel, and is backed with earth with a slope of nearly 2 to 1.

The water stands within a few inches of the top of the dam and runs over at every rise in the river. There must be 10 or 12 feet of water passing over it at times, judging from the high-water marks. Below the dam is a pile of loose bowlders which holds the leakage through the dam and forms a water cushion to receive the fall. The dirt is washed from the back of the dam at every high rise, and is at once replaced when the rise goes down, by scraping the dirt from the north side of the river. The dam backs the water up about 500 yards, the deepest hole being about 15 feet. The water is taken out on the south side 100 or more yards above the dam and carried in a cut to the sluice gate a little below the dam.

A section of the ditch made a few hundred yards below the sluice gate gave the following: top, 15.2 feet; bottom, 8 feet; depth, 2.7 feet; wetted perimeter, 16.5 feet; area, 29.83 square feet; maximum surface velocity, 2.17 feet per second; mean velocity, 1.54 feet per second. The velocity was measured for 100 feet above and below the section, where there was no very great difference in the dimensions of the ditch. The fall of the surface was found to be at this point 0.1 foot in 195, or 1 foot in 1,950, or 2.7 feet in a mile. This, with a coefficient of $N=0.03$, would give a velocity of 1.57 feet per second, which is very nearly the observed velocity of flow. This gives a discharge of 46 cubic feet per second, or 2,300 inches, estimating 50 inches to 1 foot.

Taking the estimated acreage irrigated as 2,000 acres, we have from our calculated flow a little over 1 inch per acre, which is the allowance in actual use, as above stated, and a water duty of 44 acres per cubic foot per second of flow for the water entering the main ditch. These measurements were made at but one point and can be considered as only approximate for the whole ditch. For accuracy they should be

repeated at a number of points and proper allowance made for percolation and leakage. In general, the estimate is that three waterings of 4 inches will make a crop. From the above it is readily seen that before a calculation can be made with any degree of certainty as to what water is necessary to irrigate a crop in this country, there must be further experiment and careful consideration and comparison of

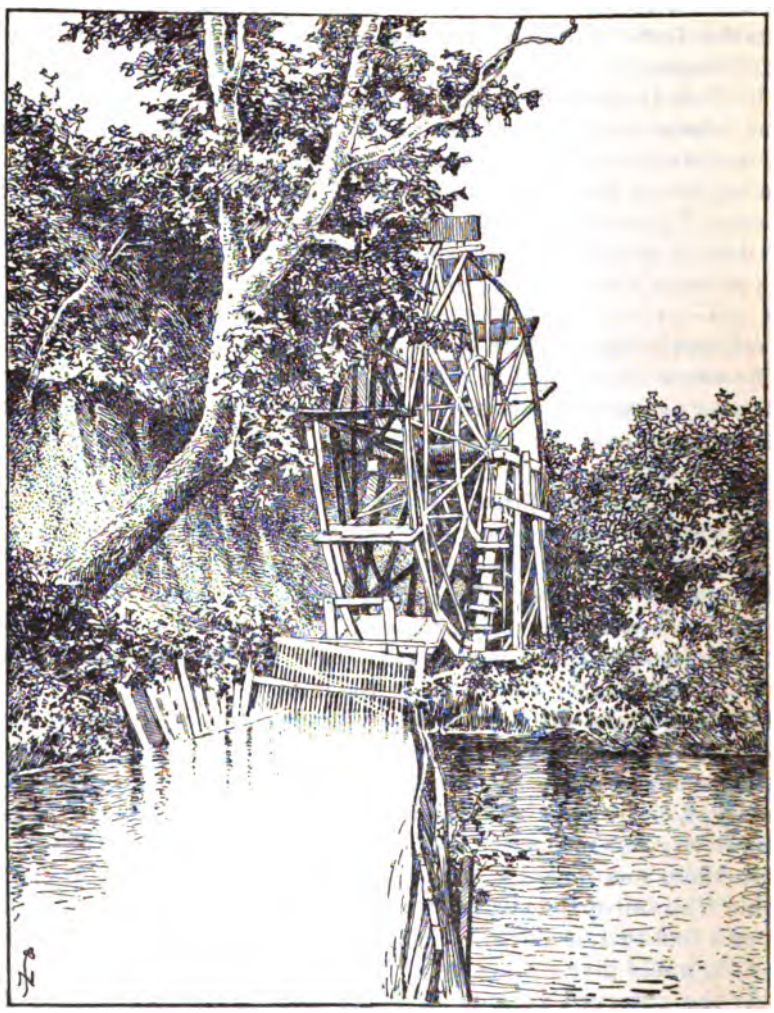


FIG. 4.—Water wheel and wing dam turning current against wheel.

soil and subsoil, percolation, evaporation, and the best method of applying the water to the crop. The duty at Menardville is, under the present system, 44 acres per cubic foot of flow per second, or a trifle under 1¼ inches per acre.

At San Marcos is found a system of water wheels for raising water for irrigation. They are all of the same type, consisting of an under-

PORTION OF WATER WHEEL, SHOWING BUCKETS RAISING WATER.

shot wheel of a size varying according to the height of the river bank. The wheel is run by the direct current of the river, which is quite swift, and is brought against the wheel either by a wing dam of planks, which turns the current against it, or by a ditch taken out about 50 or 100 yards above. The river, coming from immense springs which burst out about three-quarters of a mile above the town, as shown on Pl. I, is not subject to rises, the only flood on record having occurred when a flood in the Guadalupe backed up the water of the San Marcos for eight hours. This renders secure this seemingly unsafe way of locating a wheel. There are three of these wheels on the river, all used by truck gardeners. The wheels are of wood and are the simplest form of undershot wheels, with a metal bucket fastened to the perimeter of one side of the wheel, in front of each paddle, as shown in Pl. II and fig. 4. These buckets fill in succession as the wheel turns and empty into a trough above, thus raising the water very nearly to the height of the diameter of the wheel.

The wheel owned by Capt. John Richards (Pl. II) is the oldest and the one on which all of the others are modeled. He states that before he built it he tried a number of pumps, which required too much attention and repairs, and afterwards several kinds of water wheels, with no satisfaction until he finally hit on the present arrangement of his buckets, which has lasted satisfactorily for about ten years. The wheel runs day and night, and needs no attention save oiling twice a week. It is 20 feet in diameter and 8 feet wide, and is supplied with water by a ditch 150 yards long, taken directly from the river and running through low ground to the wheel. It pumps into an artificial reservoir of about 50,000 gallons capacity. The average speed is three revolutions per minute, and in that time it raises about 90 gallons, or 0.20 second-foot. The water is used to irrigate 3 acres of grapes and vegetables for the market.

The wheel at D. C. Garrett's place, shown in fig. 4, is larger and carries 16 buckets of 6 gallons capacity, pumping on an average 144 gallons per minute, or 0.32 second-foot. He uses no reservoir and irrigates about 12 acres in vegetables.

These wheels furnish a cheap and convenient method of irrigation, being easily built, and running expenses being practically nothing. They are highly successful at San Marcos, but would not be elsewhere where the conditions are not similarly favorable. Here the river has a swift flow and steep banks, from which the wheel may be hung with relatively little expense for scaffolding, and the stream, coming from a great spring, has an even flow summer and winter.

At Austin, the State capital, is one of the largest hydraulic works of the country, impounding water of Colorado River. Although this was built primarily for the purpose of furnishing power, there was at the same time a belief that the surplus water could be used for irrigation above the lowlands along the river at times of summer drought.

This project for thus employing the surplus flow of the stream was abandoned, if not completely destroyed, by the low water of the summer of 1896, when the surface of Lake McDonald was lowered some 5 feet below the crest of the dam. Thus, although there is an immense amount of surplus water carried by the river, it is probable that other works must be built to utilize it, for the steady increase of demands for power tends toward the requirement that the stored water shall be held for this use during the summer months.

The dam at Austin was built by the city with the intention of supplying water for municipal purposes and power for lighting and for manufactures. It is located at a point about 2 miles west of and above the city, where the river flows in a narrow valley between limestone cliffs. At this point the Colorado River drains about 40,000 square miles, and has a usual summer flow of 1,000 second-feet. In times of flood it rises to from 200,000 to 250,000 second-feet, a contingency which necessitated the construction of a strong masonry dam which could be submerged by the highest floods.

The dam is 1,150 feet long, with the crest 60 feet above low-water mark and having a maximum height of 70 feet. It is 66 feet thick at the bottom and 16 feet wide on top, constructed of solid limestone rubble laid in imported Portland cement, faced on each side and on the top with cut granite blocks from the same quarries that furnished the stone for the State capitol. In order to provide for the great volume of water coming down the river in flood times the dam was so designed as to allow the surplus water to flow over it in a sheet of uniform thickness along the entire length. To avoid the impact and erosive action of the falling water, which may sometimes be as much as 15 feet in depth at the crest, the front of the dam was given the shape of a reversed curve of ogee form. This allows the water to glide down its face without shock and expend its force in a horizontal direction against the pool in front of the toe.

There are three iron sluice pipes 36 inches in diameter inserted in the dam, near the west end, for use in possible emergencies. The total cost of the dam, exclusive of the sluice pipes and engineering expenses, was $611,300; the latter amounted to some $58,000 more. The total cost of the whole enterprise, including dam, power house, electric lighting, and waterworks system, was nearly $1,400,000. Lake McDonald, formed by the dam, is over 25 miles long and averages three-fourths of a mile wide. The power available is estimated at about 14,000 horsepower. The power house, shown in Pl. III, is located on the same side of the river as the city and just below the dam. The water is carried directly to the turbines through iron penstocks.

The water for the city is pumped from the lake into the mains, the pumps being directly connected with the turbines operating them. The management is preparing, however, to move these pumps some

AUSTIN DAM AND POWER HOUSE.

distance down the river to beds of gravel forming natural filters, from which perfectly clear water can be obtained at all times. This is the same water as that in Lake McDonald, but it is purified by filtering through these beds. It will be obtained by sinking cribs in the gravel and pumping from them by electrical energy transmitted from the power house. At present the amount of work done varies from 800 to 3,000 horsepower. This is employed for waterworks and electric lighting, and for running all the car lines and most of the manufacturing enterprises in the city, such as planing mills, printing presses, and many others. It has been demonstrated that it is cheaper for a man who uses no more than 200 horsepower to rent his power from the city in the form of electrical energy and to use an electric motor instead of a steam engine.

Up to the present time most of the earnings of the plant have been spent in improving and adding to it; but it is hoped that in the near future these will increase and materially relieve the people of the heavy burden of taxation under which they now labor and enable them to pay off the debt incurred in construction.

Another notable water power which may in the future be partly used for irrigation is that supplied by the Comal Springs at New Braunfels. These springs burst from the base of the hills at many points for a distance of a mile or more and form the head waters of Comal River. New ones can be made at any time by blasting in the limestone rock along the line of those already existing. The fall is so great for the first half mile that no difficulty is found in carrying the water by a simple canal to the point where the accumulated flow can be utilized to good advantage. At present the power is used to operate a cottonseed-oil mill, a flour mill, and an electric-light plant owned by the Landa estate, on whose property the springs are situated. The power used amounts to about 500 horsepower, which can be increased almost indefinitely, if desired.

SAN ANTONIO AND VICINITY.

Under this head is included a description of irrigation works at San Antonio, and also in the areas southerly and southeasterly near San Antonio and Guadelupe rivers down to the Gulf coast. The irrigation ditches at San Antonio are historically the most interesting in the State, for here are found the earliest systems and structures, which have been in use for more than a century. Additional interest is derived from the association of the ditches with the early missions and with the efforts of the Franciscan fathers to settle the Indians upon these lands and employ them in agriculture. The old missions, now in ruins, were rendered habitable by these ditches, and the lands adjacent were the garden spot of the frontier, making possible the growth of the city which now is the center of civilization and trade of the Southwest. These ditches are now almost completely concealed

by the ancient trees and the luxuriant verdure that line the banks, and through the lapse of time they have assumed the character of natural drainage channels, so that it is almost impossible to believe that they were artificial works. The facts concerning the origin and present condition of these ditches were obtained mainly from Mr. Z. O.

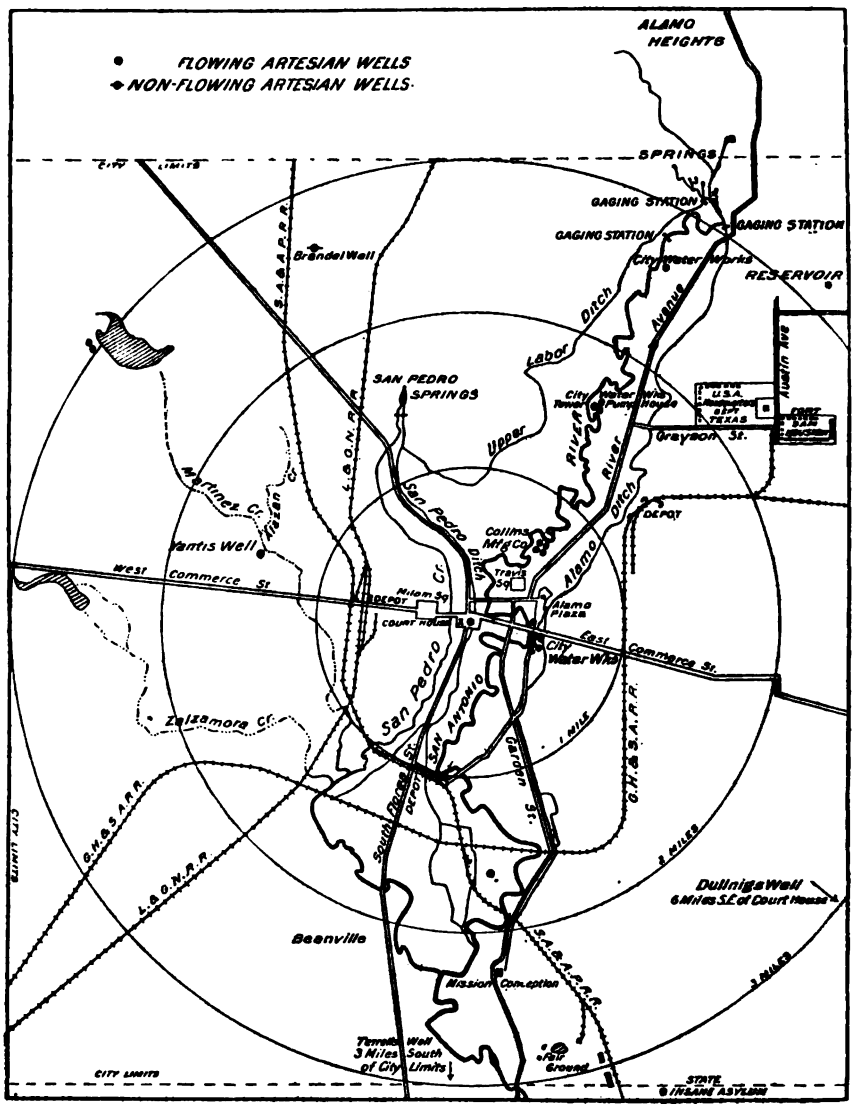


FIG. 5.—Map of ditches and artesian wells at San Antonio.

Stocker, of San Antonio, who has made a thorough study of them, both from an interest in the subject and with a view to developing irrigation enterprises in the vicinity. A view of the river, illustrating its size and character, is given in Pl. IV.

SAN ANTONIO RIVER AT MILL BRIDGE.

The original mission ditches built by the Franciscan fathers between the years 1716 and 1744 are the Pajalache or Conception ditch, the Alamo Madre, the San Jose, the San Juan, and the Espada ditches, all dug to supply the lands belonging to the respective missions. In addition to these mission ditches there was one, the San Pedro, which supplied water to the Villa Capital de la San Fernando, settled in 1730 by the emigrants from the Canary Islands; and one built much later than any of the others under the superintendence of the governor, Baron Ripperda, for the supply of the citizens of the town, and called the Upper Labor ditch.

Beginning at the head of the San Antonio River, as shown on fig. 5, this last-named and most recent of the Spanish ditches is the first encountered. It was begun in 1776 and was ready for use in 1778, under the general direction of the royal governor, care having been taken that no infringement of the prior rights of the five missions and Canary Island settlers should occur. The work was done by those citizens who desired to enlist themselves for that purpose, each furnishing his own tools and at the completion of the ditch receiving a share of the land commanded by the ditch under royal grant, on the condition that he should aid in keeping the ditch and all its appurtenances clean and in repair, and hold himself, with one horse, arms and ammunition, in readiness at all times to meet the enemies of his king. The lands were divided into lots called "suertes" (suerte meaning luck or chance), each one containing the amount of land that could be irrigated by the ditch during a given space of time, usually a day, but sometimes less. The assignment of suertes was always accomplished by lot. The original grade and side slope of these ditches are unknown, but the latter is quite steep, probably about ¼ to 1, or at most ½ to 1, yet on all of them the banks, owing to the character of the soil, have withstood the elements remarkably well. The ditches will be described in the order in which they are met with in descending the river.

The Upper Labor ditch takes its water from one of the large springs at the head of the river by means of a loose-rock dam. The ditch follows the contour of the land on the west side of the river and ends in the San Pedro Creek, and once commanded about 600 acres of land, of which only about 100 acres are now irrigated and used as truck gardens. Water rent is $2 per acre. In 1877 the city replaced the old loose-rock dam by a masonry one and built an extension to the ditch, called the Alazan branch. The latter was abandoned in 1896, because the land irrigated was devoted to residences.

The Alamo Madre ditch, built between 1718 and 1744 to supply water to the Alamo Mission and irrigate its lands, derives water from the river on the east side, at a point just opposite the Labor ditch, by means of a low dam. The ditch then follows the contour of the land and runs through the business part of the city. Its length is 6 miles,

and it irrigated about 900 acres, of which only about 220 are now cultivated.

San Pedro ditch was commenced in 1738, and furnished water to the Villa de la San Fernando, the parish church of which, now

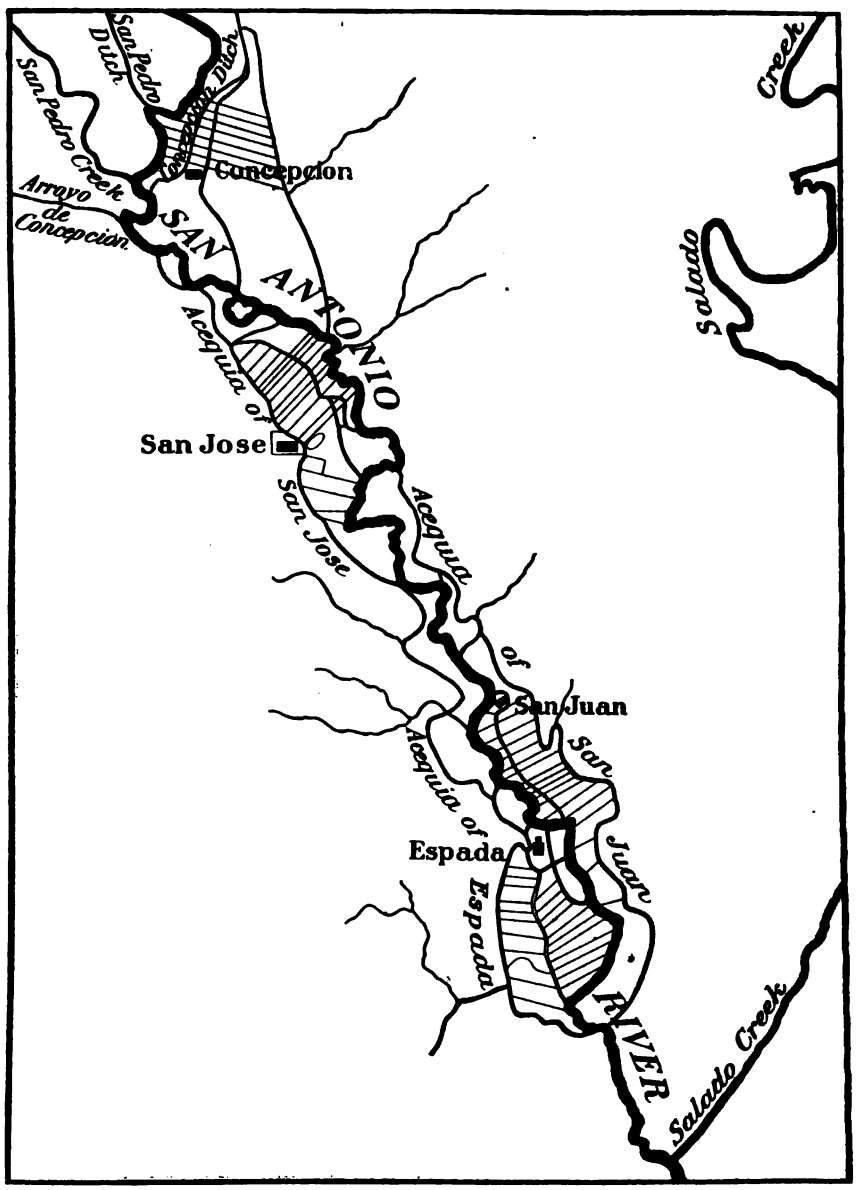


FIG. 6.—Mission ditches below San Antonio.

called the San Fernando Cathedral, is the geographic center of San Antonio. The water for the ditch, taken from the San Pedro Creek, follows down the east side of this and runs through the center

OLD STONE AQUEDUCT CARRYING ESPADA DITCH ACROSS PIEDRAS CREEK.

of the city, irrigating 430 acres of land below town. Its length is about 4 miles and it is 2 feet deep and 6 feet wide. The management of the above-mentioned ditches long since passed out of the hands of the landowners and into those of the city authorities, and is intrusted to a ditch commissioner appointed by the mayor. The annual water rent is $2 per acre. The general location of this and lower ditches is shown in fig. 6.

The next ditch of importance is the Concepcion, built in 1729, and abandoned in 1869 after being in use one hundred and forty years. This was discarded on account of the dam, which was in the center of the city, causing much damage from overflow when there was a rise in the river. This ditch was constructed to furnish water to the Mision de la Concepcion, and was the largest of all the old ditches.

The San Jose ditch was built, probably, about 1720, to supply water and irrigate the lands of the mission of that name, 5 miles below the town. The water was taken from the San Antonio River, on the west side, at a point about 2 miles above the mission, and, following the contour of the land, ran through the mission and returned again to the river about 1 mile below, after irrigating 600 acres. This ditch was abandoned in 1860 on account of the repeated washing away of the loose-rock dam across the river.

The San Juan ditch taps the river on the east side at a point opposite the mission San Jose. It follows the contour of the land and carries its water down to the mission of the same name. It was built in 1731 and is still in use. It irrigates over 500 acres of land, which rent with water for $7.50 an acre per annum.

The Espada is the last ditch taken from the San Antonio River, though one of the earliest in point of construction. It takes its water from the river on the west side at a point 6 miles below the city by means of a loose-rock and brush dam 270 feet long, and built on a natural ledge of rock extending across the river, making the total height of the obstruction 8 feet. This dam consists of layers of brush weighted by loose rock, with gravel and earth thrown in in front, forming a very effective dam, the rock becoming gradually cemented together by a deposit of lime salts from the water. It crosses Piedras Creek on a stone aqueduct, shown in Pl. V, which consists of a series of massive arches that seem in as good preservation to-day as when constructed, more than a century and a half ago. The old Mexican who lived close by asserted that he had seen the water in the creek, in time of flood, flow over the top of the aqueduct, sometimes topping it by as much as 6 feet.

This ditch fell into disuse about twenty years ago and was abandoned until 1895, when A. Y. Walton, jr., who owned several suertes of land, organized the owners of the lands commanded by it into a company (the Espada Ditch Company), cleaned out, widened, and deepened the old ditch, repaired the dam, and made some change in its course, the total cost being about $3,000. The ditch is now 3 miles

long, with a bottom width of 5 feet, and carries 10 second-feet of water. It commands 400 acres, of which 300 are irrigated. The annual cost of keeping the ditch in good working order amounts to 25 cents per acre. The principal crops are 100 acres in corn, 150 acres in cotton, a considerable area in Johnson-grass meadows, and the rest in truck gardens for the city market. The appearance of the crops under these ditches, even in a time of such abundant rainfall as the first half of 1897, is a remarkable proof of the value of irrigation. The land is mostly an alluvial valley soil, very productive when watered. On irrigated fields it is customary to make at least a bale of cotton to the acre, while the average on unirrigated fields for the last five years has hardly been more than one-fourth of that. Truck farmers raise all kinds of vegetables, from early spring until frost, in the greatest profusion.

Three-fourths of a mile above the head of the dam which supplies Espada ditch is the head gate of the Trueheart ditch, the only modern canal taken from the San Antonio River. This was begun in August, 1895, and completed in May, 1896, at a cost of about $18,000; it has a total length of 10 miles and is designed to carry 30 second-feet of water. There is no dam, the canal entering the river directly and the head gates being of wood with brick abutments. The cut for the first 3,000 feet averages 14 feet in depth, with a bottom width of 6 feet. It now carries much less than the registered amount of water, a freshet having washed away the head gates and largely filled up the first few hundred feet of the canal, allowing only about 1.5 second-feet of water to enter it. This is, however, amply sufficient for the land at present under irrigation, which is this year (1897) about 400 or 500 acres, though the canal commands 1,500 acres. The principal crops are alfalfa, Irish potatoes, corn, cotton, and vegetables. The water rights are held at $15 per acre, and the annual rental is $2.50 per acre, but all of the land irrigated so far belongs to the owners of the canal. This canal has seven flumes, one of which, shown in fig. 7, is 1,000 feet in length, with an average height of 20 feet. It carries the water across a valley at Minita ranch, 11 miles from San Antonio. The slope is given as ½ to 1.

There is some irrigation practiced in and near San Antonio from artesian wells, a view of one of which is shown on Pl. VI.[1] The most extensive is that of H. D. Kampman, who has a well on his place with an estimated flow of 1½ million gallons in twenty-four hours under 20 pounds pressure, or 2.32 second-feet. This well is 970 feet deep, and was drilled at a cost of $3,000. It is allowed to flow on 250 acres of the owner's land, this, being in alfalfa, needing only a small portion of the water. It has been stated that this well would irrigate 1,000 acres of land through a system of ditches or storage tanks. A

[1] For details see paper by Robert T. Hill in Part II of Eighteenth Ann. Rept. U. S. Geol. Survey, p. 290.

ARTESIAN WELLS AT CITY WATERWORKS, SAN ANTONIO.

second well near the same place discharges about one-third as much water.

Below the city of San Antonio is an irrigation farm which is probably unique in the State, but which may be considered as being typical of others in various parts of the United States. This is the sewage farm, to which is brought for purification and disposal the waste from the city. This method of disposal is one which is rapidly growing in favor, not only in arid and semiarid regions but in humid countries as well, being extensively practiced in New England and in various European countries. The city sewage farm consists of about 400 acres, subdivided into a number of small tracts or gardens sufficient in area to take all of the present output of sewage. These gardens occupy a space about 400 feet square. Near them are a

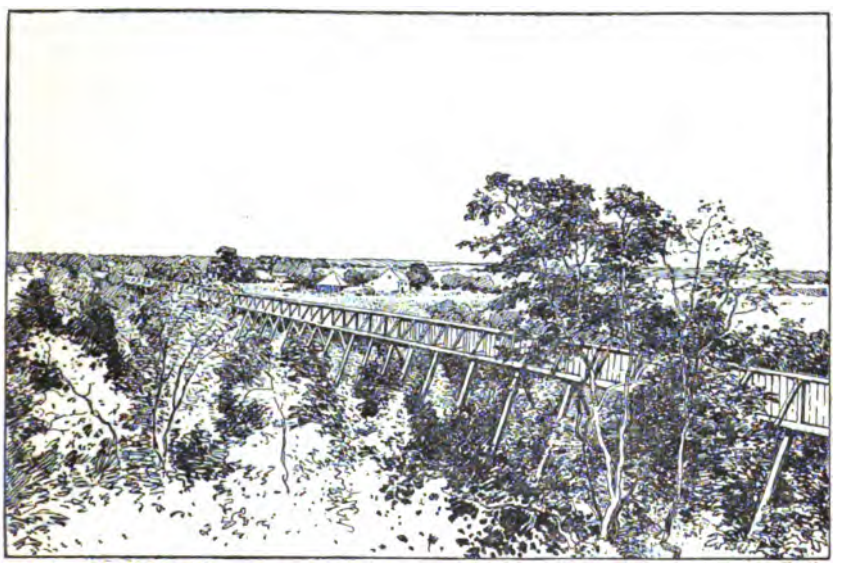


FIG. 7.—View of flume on Trueheart ditch.

number of broad basins surrounded by low dikes to receive the flow from the sewer outlet when water is not wanted on the gardens. It is intended to plant most of these basins in crops which will not be injured by a considerable amount of water, so that the surface will be covered by vegetation throughout the greater part of the summer.

Along San Antonio River below the city are several pumping plants operated by steam. A small one at Elmendorf, owned by C. M. Rounds, is very conveniently arranged for supplying water to a dwelling house and also for irrigating purposes. The water is pumped into an elevated wooden cistern near the river bank and thence piped to another cistern at the house and to the garden and orchard.

Thirty miles below, on the same river, near Floresville, in Wilson County, are reported two more similar plants. That of A. G. Pickett

is the more important. It was set up in 1893 and consists of a 40-horsepower steam boiler, operating a Blakeslee duplex steam pump, which is connected to the boiler by a 2-inch steam pipe. From 12 to 15 horsepower only is used at present, it being the intention of the owner to extend his plant by the addition of more pumps as more land is brought under irrigation. The average distance from the pump to the water is 15 feet, and the average lift is 50 feet. There is no reservoir, the water being pumped directly into the ditch. The total cost of the plant is estimated at $2,500, and it requires one man at a cost of 12½ cents per hour to operate it. The pump is covered by high water in the river from two to four times a year. This plant was built with an idea of irrigating from 300 to 400 acres, and has sufficient boiler capacity, but will require additional pumps. The present pump has a 7-inch suction pipe with a 6-inch discharge, and is estimated to pump about 750 gallons per minute, or 1.67 second-feet. The present capacity is sufficient to irrigate from 75 to 100 acres. The annual cost of water is estimated at from $2 to $6 per acre, according to the amount of rainfall and pumping done. There has been difficulty in getting on the place tenants of sufficient intelligence and progressiveness to use the water on their crops or to grow crops that will repay the cost of water and labor. They prefer to continue planting cotton.

The other plant is located 7 miles from Floresville, and is owned by W. E. Crandall and J. O. Dewees. It was first used in 1896, and consists of a 10-horsepower boiler operating a Blake pump set on the river bank at a distance of 70 feet from the boiler, and with a capacity of from 75 to 100 gallons per minute, or from 0.17 to 0.22 second-foot. The average distance from the pump to the surface of the water is 22 feet and the total lift is 48 feet, the water being pumped into a reservoir 50 feet long, 50 feet wide, and 8 feet deep, formed by building an earthen wall on all sides. The total cost of the plant is estimated at $295, and it is used for raising vegetables.

About 50 miles easterly from Floresville is located the enterprise of the Buchel Power and Irrigation Company. The plant is located 3 miles west of Cuero and is to consist of a permanent stone-and-concrete dam across the Guadalupe River, which, when completed, will be 165 feet long on the crest, or 200 feet long including abutments, 23 feet high, and will raise the water 10 feet above the usual water level. The dam was begun in December, 1896, and in June, 1897, was about one-half completed. The 10-foot head of water will be used to run turbines which will operate force pumps, raising the water a total height of 60 feet to a reservoir about 500 feet distant from the dam. From this reservoir canals will lead to the land to be irrigated. The reservoir is to be an artificial one with earthen banks, and is calculated to have a capacity of 10 million gallons, or 30 acre-feet. The area to be irrigated consists of rich valley land along the east bank of

the Guadalupe River, 2,000 acres of which are owned by the company and will be first put under ditch. If successful with this tract, the company expects to extend the system to cover 2,000 more acres of the same valley. The growth of all varieties of crops is contemplated, but especially alfalfa, fruits, and vegetables. Guadalupe River has an estimated average flow of 800 second-feet, and with the 10-foot head it is expected to develop about 700 horsepower. Probably one-third of this will be used for irrigation, the remainder being converted into electrical energy and carried to the town of Cuero.

South of Cuero about 30 miles, near Goliad, G. W. Simmons has put in a plant consisting of a 2½-horsepower gasoline engine and a pump with a capacity of 33 gallons per minute, or 0.07 second-foot. The water is obtained from a small stream across which has been placed a

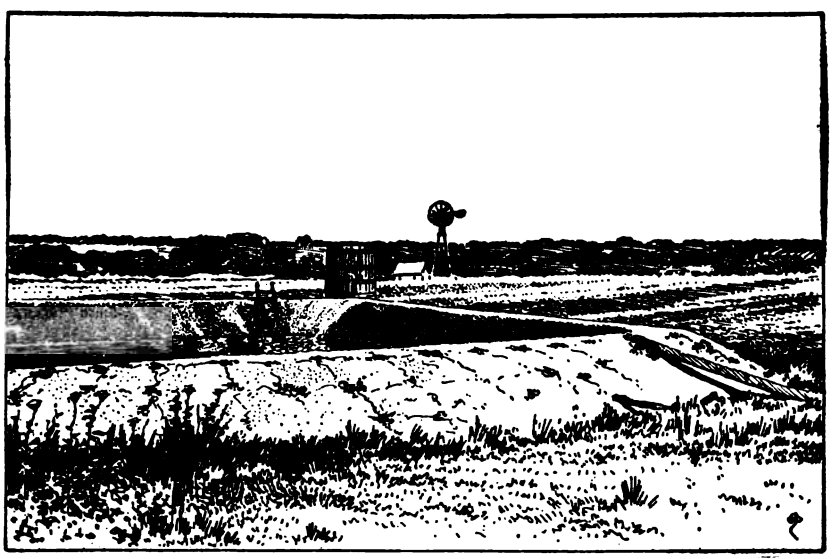


FIG. 8.—View of irrigation tank at Beeville experiment station.

wooden dam 60 feet long and 3 feet high, and is raised 20 feet and pumped directly into the ditch. The total cost was $450, and the plant, while it has not been fully tested, is expected by its owner to irrigate 10 acres.

In Bee County, at the State subexperiment station, under the direction of S. A. McHenry, superintendent, is a pumping plant erected for the purpose of irrigating the orchard and lands devoted to horticultural experiments. It consists of a 5½-horsepower gasoline engine and a windmill, pumping from a well 74 feet deep, in which the water stands 32 feet. The pump has a cylinder 3½ inches in diameter by 36 inches long, with a 24-inch stroke when run by the engine and a 9-inch stroke when the windmill is used. The capacity with the engine is 24 gallons per minute, or 0.05 second-foot. The water is forced 600 feet

to a reservoir at a height of 16 feet above the top of the well. The reservoir is 32 feet long, 52 feet wide, and 8 feet deep, and contains about 100,000 gallons, 0.3 acre-foot. It was built by excavating 4 feet deep and building earthen walls of the same height around it, the total cost being $140. On account of the very porous nature of the soil, all tanks in this region must be lined with some artificial material—cement, asphalt, or coal tar. That at the experiment station (shown in fig. 8, p. 49) is lined with a mastic consisting of 73 per cent sand, 25 per cent coal tar, and 2 per cent lime. The sand and lime are mixed together and the tar is boiled until it will string and is mixed hot with the other ingredients. It is spread on the bottom and sides while hot at the rate of 52 pounds to the square yard. On top is put a varnish formed by boiling pure coal tar and flashing it with a lighted match to burn off the light oils. The plant was completed in 1897 and has been used but little yet. It is estimated that 20 acres can be handled in the present condition of the plant. The engine uses 5 gallons of gasoline in one hour.

On the Kaylor and Heldenfells place, near Beeville, is a circular tank 80 feet in diameter and 12 feet deep in the center. It is lined with cement and supplied with water by two windmills pumping from wells. It commands 40 acres in orchard and vineyard, but has been used very little of late for irrigating and not at all for the grapes. An attempt has been made to subirrigate by means of wooden troughs, but this method has fallen into disuse. In Beeville, W. C. McDowell, since 1893, has been irrigating his truck garden, consisting of one-half acre. Water is raised by a windmill, pumping from a 70-foot well into a wooden cistern of 2,800 gallons capacity.

NUECES RIVER AND LOWER RIO GRANDE.

Nueces River receives the drainage from that portion of southern Texas lying between San Antonio River on the east and the lower Rio Grande on the west. For convenience of description the irrigation projects within this drainage basin are given in geographic order from the head waters to the Gulf, and after these the similar enterprises along the Rio Grande from the mouth of Pecos River southeasterly.

On the head waters of Nueces River, about 4 miles northeast of Leakey, is a brush-and-stone dam across Frio River 45 feet long and 2 feet high, built in 1896. This supplies a ditch 2 miles long, with a top width of 5 feet, bottom width of 3 feet, and depth of 3 feet. It was first used in 1897, and commands 300 acres, of which 115 have been cultivated. Sixty acres are in cotton, 50 in corn, and the remainder in oats and vegetables. Two miles below on the same river is a ditch irrigating 50 acres. Toward the east, on Turtle Creek, in Kerr County, a small amount of land is irrigated, and in Bandera County 300 acres are irrigated by small ditches taking water from Frio River.

At Batesville, and southerly at Carrizo Springs, on the west side of

Nueces River, is a considerable amount of irrigation, or rather a large number of irrigation plants operated by windmills, and at the latter place some irrigation from flowing artesian wells. The appliances are of the usual type, and the acreage commanded by each man is very small, and consequently expensive. In Zavalla County are also 3 miles of ditches and 500 acres under irrigation from artesian sources.

A number of schemes have been proposed for bringing under irrigation considerable areas along Nueces River, especially about the middle portion of its course. The success attained by the present methods, though crude, has been such as to encourage others to attempt the construction of better devices. Actual work has been held back to a considerable extent by the defective laws, but since the passage of more favorable legislation in 1895 several projects have been revived.

Nueces River, with its tributaries, has a catchment area of about 20,000 square miles. The amount and distribution of rainfall throughout this territory is such that, with the sandy soil, a comparatively small amount flows, even in the main stream. Few of the tributaries can be said to be perennial in flow, many becoming nearly or completely dry at certain seasons of the year. The Nueces itself and several of its tributaries, such as the Frio and Lena, head in large springs on the edge of the plateau. Here are admirable localities for diverting water for irrigation. On leaving the plateau country the streams tend to diminish, a considerable portion of the water being lost in the sandy channels, occasionally reappearing when forced to the surface by impervious strata. Throughout the area to the south of the line of the Southern Pacific Railroad the perennial flow is so small or uncertain that irrigation on a large scale must depend upon storage reservoirs holding storm waters.

By consulting a map it will be seen that Nueces River flows from its head in a general southerly direction, but at a point about 35 miles west of Cotulla it turns toward the east. At this point the wagon road between Cotulla and Carrizo Springs crosses by means of a bridge. The region west of the river contains a number of long, deep, narrow bodies of water, known as Soldier, Espantosa, and Caimanche lakes. The two former are practically parallel to the course of the river and are connected by a slough or arroyo, while the northern end of Espantosa Lake is connected in a similar manner with the main channel of the river. In time of flood the water rushes through the connecting channel into Espantosa Lake and returns again to the river, either through an independent channel which issues from the south end of Espantosa Lake direct to the river, or through Soldier Slough or Lake, which in its turn discharges its water through a channel connecting it with the river. In other words, in time of flood the river splits into two, one portion passing through the main channel

and the other being diverted to the west, passing through the lakes and returning again to the river.

Caimanche Lake is quite different in its nature from the two just mentioned. It lies northwest of the Espantosa about 3 miles, and at an elevation of 15 feet above the latter. This lake gathers the water of a large drainage basin, extending from the Rio Grande divide on the south to many miles beyond the Southern Pacific Railroad on the north, a region containing springs and an easily obtainable supply of artesian water. Its water is discharged through Espantosa Slough into Nueces River, and ordinarily its volume is double that in the main channel of the river itself before its junction with Espantosa Slough. It is proposed to convert Caimanche Lake into a storage reservoir by means of an earthen dam 1¾ miles in length and 20 or 25 feet in height. The area of the reservoir at the height of 170 feet

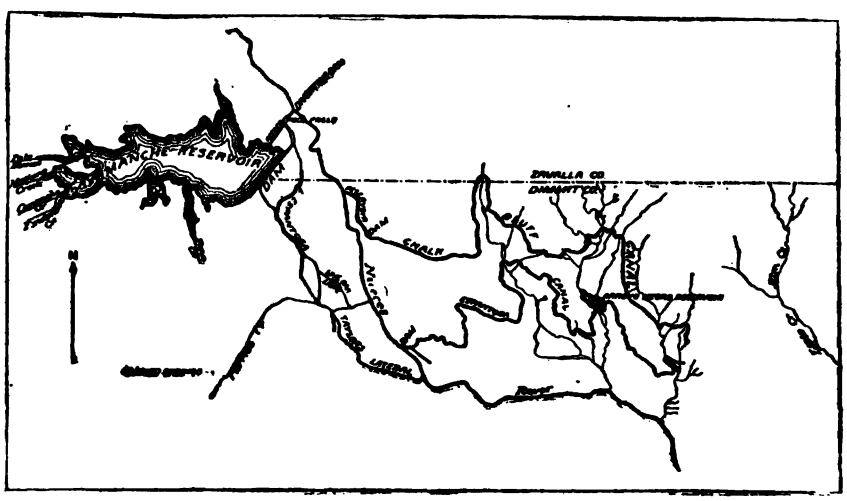


FIG. 9.—Map of the proposed Caimanche reservoir and canals.

above an assumed datum will be 8,500 acres; at 177 feet, or with a dam 20 feet high, it will be 10,000 acres; and at 185 feet it will be 12,500 acres. The original estimates were made for a 20-foot dam, but it has since been concluded that a dam 25 feet high is equally feasible and will make a much greater volume of water available. The spillway will be constructed 5 feet below the crest of the earthwork. Though in possession of no accurate data as to the hydrography of the drainage basin, the projectors are confident that the flood discharges are sufficient to fill the reservoir several times in the course of a year. In addition to the natural drainage of the basin, they expect to avail themselves of the waters of the main stream of the Nueces.

The old channel, connecting the northern extremity of Espantosa Lake with the river, has been already mentioned. Except in flood

seasons, no water enters the lake through this channel, there being a high, rocky barrier in its center, known as Rock Falls. By constructing a diversion dam on the Nueces River below the point where the slough to the Espantosa leaves it, and by cutting a channel 1¾ miles long from the upper side of Rock Falls into Caimanche Lake, the river and the reservoir can be connected.

To use the water so stored it is proposed to pass it down the slough connecting Caimanche and Espantosa lakes, through the Espantosa, and finally into the river channel. From the channel it is to be diverted by means of a dam some distance below the Carrizo Springs bridge into a canal on the east bank of the river. Soldier Slough,

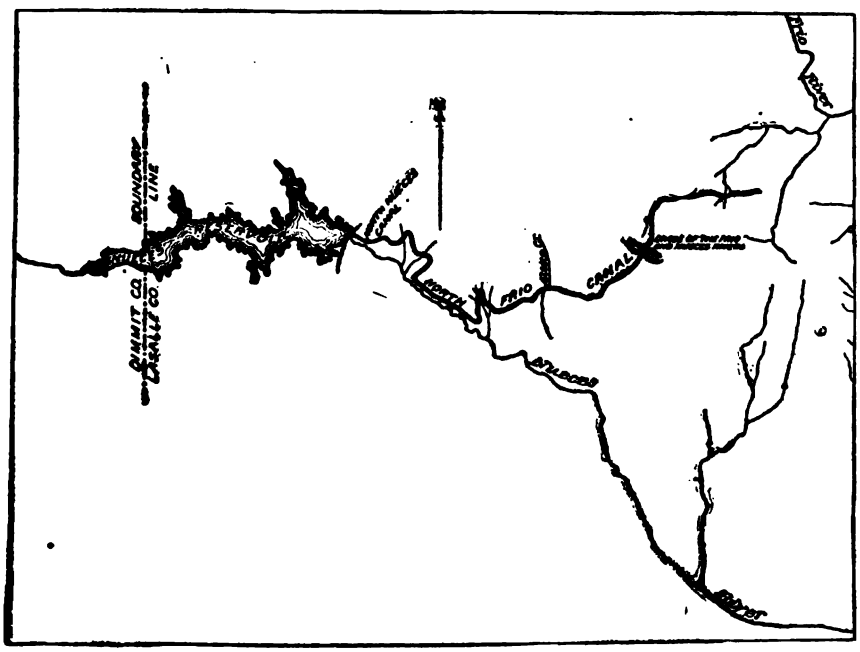


FIG. 10.—Map of proposed Nueces reservoir and canal.

already mentioned, must also be closed by a dam of the same height as the diversion dam on the river. These dams themselves would impound a considerable quantity of water; just how much has not been estimated. At the lower diversion dam the company expect to avail themselves of, first, the water impounded by the dam itself; second, the natural flow of the river; and, third, the storage water of Caimanche Lake. After a diversion line of less than a mile the water of the canal can be taken out on the land. The grade adopted is 1 foot to the mile. The land covered by the canal is among the richest in Texas, well adapted for corn, cotton, sugar, or alfalfa, and the upper-line canal would reach very fine fruit lands. Allowing as much as 2 feet of water per acre per annum, it is estimated

by the promoters that there will be sufficient to irrigate 50,000 acres.

About 35 miles below the diverting dam on the Nueces River turning water into Caimanche Reservoir, the river passes from Dimmit County into Lasalle County, and for about 10 miles below the county line the valley widens, the topography being favorable for the creation of a reservoir. By constructing a masonry dam 2,600 feet long and 50 feet high in the center, it is proposed to create what is known as the Nueces Reservoir, having an area of 12,700 acres. Such a reservoir would receive all of the waste and seepage water from the storage works and irrigation canals above, but, being situated on the main line of the river, would be subject to floods. It is proposed to take out water on the north side of Nueces River by means of a canal, which, winding along the slopes, ultimately passes northeasterly over the divide between the Nueces and Frio rivers, thus commanding a great area of agricultural land. The expense per acre irrigated is estimated to be about double that of the Caimanche project.

About 100 miles farther down Nueces River, at the junction with Frio River, surveys have been made by private capital to ascertain the feasibility of constructing an immense system of storage reservoirs with a view to the irrigation of the valley lands and also that portion of the coastal plain which can easily be reached by high-line canals from the uppermost of the intended works. Fourteen storage reservoirs are proposed for this system, and the sites for these have been examined, located both above and below Live Oak. Their total holding capacity, as stated by William Harrison, who has made all of the surveys, is approximately 1,792,300 acre-feet. Though of so comprehensive a nature, the project can be completed in sections should sufficient water be available, each part becoming a source of revenue possibly years before the final completion of the system. The two most important of the proposed reservoirs will be those formed by permanent masonry dams across the Nueces and Frio rivers, respectively, at what are probably the outlets of ancient lakes, through the beds of which the rivers flow.

The total area which it is estimated may be brought under irrigation by the system of canals supplied by these reservoirs, if filled, is something over a million acres. The soils are principally of three general characters, known under the local names of black mesquite, sandy loam, and resaca lands. The black mesquite comprises most of the coastal slope and valley lands of this region. It is a dark, sandy loam of great depth and richness, easily cultivated, and capable of producing a considerable range of crops. The sandy loam proper is found in the live-oak lands, and is also fertile, though not so well adapted to a variety of crops as the black-mesquite soils. The resaca lands are dark and waxy, being composed of river silt, and possess the fertility always found in such soils. They have been but

little cultivated as yet, owing to their liability to overflow. This latter fault could be remedied by the building of storage reservoirs, which would largely control the flood waters.

Farther down the river is the pumping plant of the Grover Irrigation Company, the most extensive of its kind in this region. It is located on Nueces River, 8 miles north of Mathis, and consists of a 100-horsepower boiler and a 75-horsepower engine, operating, by means of a belt, as shown in fig. 11, a Menge pump with an estimated capacity of from 5,800 to 6,700 gallons per minute, or from 12.92 to 14.92 second-feet. The pump is set in a well 8 feet in diameter, on the banks of the river, and connected with the water in the river by a tunnel 4 feet square. . The average lift is 48 feet. There is no res-

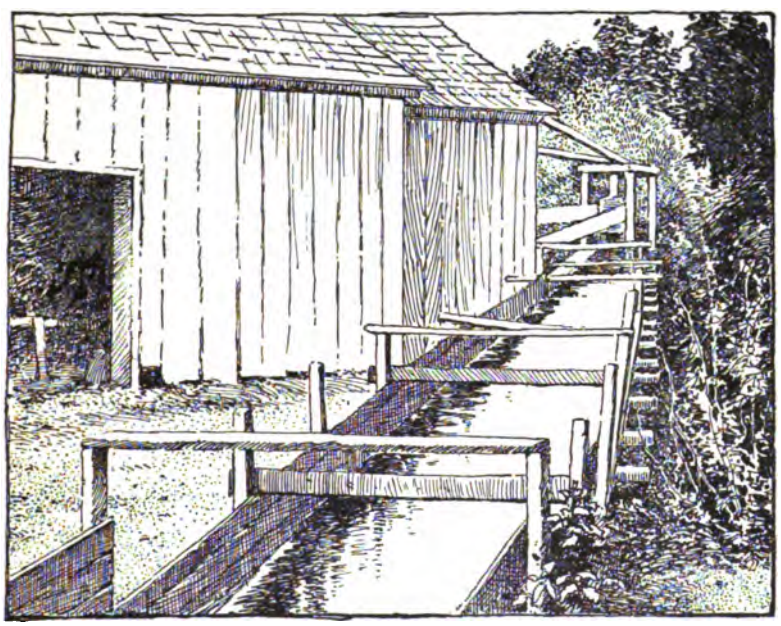


FIG. 11.—Pump and flume on Nueces River.

ervoir, the water being pumped directly into the ditch. The total cost of the plant is given as $5,000, and the running expenses, including engineer at $1 per day, fireman at 75 cents per day, 3 cords of wood at 60 cents, and 70 cents for oil and incidentals, amounts to $4.25. The manager states that he has watered 10 acres in twelve hours on land located near, but never more than half that amount on a tract three-fourths of a mile distant from the pump. This is apparently a low efficiency. The total length of the main ditch is 6,300 feet, with a top width of 6 feet and a bottom width of 2½ feet. It carries about 2 feet of water. This plant has not had a thorough test, as it has never been run steadily. Each individual owner has the use of it alternately for twenty-four hours. It is designed to cover

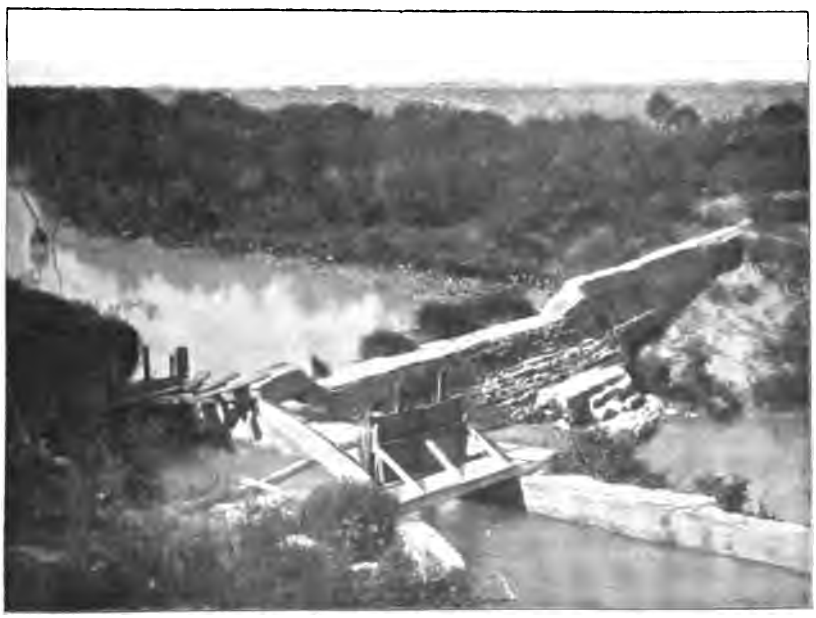
500 acres, but not more than 70 acres have ever been watered. The principal crops were corn and the vegetables of a truck garden, also a young orchard and vineyard. The corn is irrigated about twice in a season, but in 1897 it was irrigated only once.

Five miles west of Mathis, on the same river, is a pumping plant owned by S. G. Miller and Lon C. Hill, which was built in 1893 and consists of a 40-horsepower boiler connected directly by a steam pipe with a double-action pump having a capacity of over 134 gallons per minute, or 0.29 second-foot, lifting the water a total distance of 39 feet at low stages of the river. The total cost of the plant was about $3,000, and it commands 140 acres in cultivation, of which not more than 70 acres have ever been irrigated. One of the owners states that he has had three years' experience irrigating vegetables, and has not made anything out of it, owing mainly to frosts. Lack of railroad facilities and difficulty of getting goods on the market in good order have been other detriments. He claims that it is a question whether irrigating by steam will pay when raising the ordinary crops of corn and cotton. The continual expense attached to it is too great. Experience has taught him that a man can not irrigate more than 4 acres per day of twelve hours with 1 million gallons, or 3 acre-feet, of water. Ribbon cane has here been found to be the surest and most paying crop tried.

On the Rio Grande below the mouth of Pecos River one of the most important irrigated areas is that along San Felipe Creek near the town of Del Rio. This short creek is formed by four large springs about 1 mile east of the town, within one-fourth of a mile of one another. In the 4½ miles from the springs to the Rio Grande the fall of the stream is 62 feet, thus furnishing an excellent water power for manufacturing. There have been four ditches taken out, two of which are for irrigation. These are supplied with water by means of two permanent masonry dams, 65 and 150 feet in length, respectively, and each 8 feet high. The first-named, shown on Pl. VII, *A*, is nearest the springs and is the starting point of the Madre ditch; the second, about a mile below, supplies the San Felipe ditch, as shown by Pl. VII, *B*.

These systems of water supply were first used in 1879. They are owned by the San Felipe Agricultural, Mechanical and Irrigation Company, in which the shares are held by owners of the land commanded by the ditches. The total cost of the enterprise was about $25,000, and the annual cost of maintaining it is about 50 cents per acre per annum. The main ditches measure about 4 miles in length and are 10 feet wide at the top, have perpendicular sides, and carry about 2 feet of water. The laterals are four in number, with an average width of 4 feet and a total length of 6 miles. The total area irrigated is 3,600 acres, in meadow, cotton, corn, gardens, orchards, and vineyards.

A. DAM SUPPLYING MADRE DITCH AT DEL RIO.



B. DAM FOR SAN FELIPE DITCH AT DEL RIO.

There are about 3,000 acres of irrigable land unutilized on the east side of San Felipe Creek. The land has mainly what is called an "adobe" soil. It is fertile when watered and seems peculiarly adapted to the grape and the pear. All kinds of fruits and vegetables are grown in profusion. On June 15 melons, plums, and apples were ripe. The impression made on the traveler who comes from the droughty and sun-scorched plains to such a spot is not soon forgotten. This cultivated tract has been so isolated from the rest of the agricultural world that none of the diseases which so reduce the profits of the grape or fruit grower elsewhere have been introduced as yet. Grapes produce from 6,000 to 10,000 pounds to the acre, and are mostly made into wine, the above yields giving from 10 to 16 barrels of wine.

East of Del Rio an attempt made to use the waters of Pinto Creek has been unsuccessful because the supply failed just at the season when it was needed. Dams for the purpose of storing the flow of the creek for use in the summer are necessary before anything further can be done. On Mud Creek, C. Vivian, by means of a solid masonry dam 100 feet long, irrigates several hundred acres of land.

At Eagle Pass, about 60 miles below Del Rio, there is a promising enterprise for irrigating a considerable area from the Rio Grande. This river, though dry each year near El Paso, has here a minimum flow of not less than 3,000 second-feet, due mainly to its tributaries, the Pecos and Devil rivers, in Texas, and the Concho, in Mexico. The company building the canal is called the Eagle Pass Irrigation and Waterworks Company. It is proposed to take out a canal with a capacity of 200 second-feet at a point on the river 35 miles above Eagle Pass, where a ledge of rock furnishes a natural dam site and opportunity for locating regulating works. From there the canal is brought down for 12 miles along the base of the hills, which here skirt close to the river channel. Two and one-half miles from its beginning it will empty into Pinto Creek, which will be dammed and will form a settling basin for the coarser silt and sand.

The dam across Pinto Creek will contain scouring sluices for the purpose of keeping the channel free from sediment and of letting the flow of the creek pass in time of flood. At the end of 12 miles the canal comes out on the valley to be irrigated. An old lake bed is surrounded by a semicircular line of ridges which abut on the river at the northern and southern ends. A similar line of hills bounds the Mexican side of the valley. Through this valley the river has cut its channel some 40 feet below the surface, leaving two-thirds on the Texas and one-third on the Mexican side. The canal is designed to skirt along this boundary line of ridges to the end of the valley, where it empties into the river after irrigating 20,000 acres. There is a plan to enlarge it at some time in the future and carry it to Eagle Pass to irrigate some 100,000 acres. The total length of the main canal, as it is to be built now, is 28 miles, with an average

bottom width of 25 feet and carrying 3½ feet of water. It was begun in 1888, when 3½ miles were completed, and the work was then temporarily abandoned. There is little rockwork, and the expense will not be excessive. The estimates for the main canal complete are about $133,000. The side slopes are to be 1½ to 1 and the grade 13 inches to the mile. This is expected to give a current sufficient to largely prevent the deposition of silt from the water before it reaches the land. The land is very nearly level, with a descent down the river of 3½ feet to the mile. The soil is a fertile alluvial loam. The company, which owns all of the land to be irrigated, expects to largely reimburse the shareholders by selling farms of from 40 to 100 acres in area. The annual charge for water will be $1.50 per acre.

At Laredo, about 100 miles below Eagle Pass, considerable interest has been manifested in irrigation by means of pumping. One of the largest plants is that owned by Albert Urbahn, which was completed in 1897 and consists of an 80-horsepower boiler, operating a pulsometer with a nominal capacity of 1,000 gallons per minute, or 2.23 second-feet. The steam is conveyed to the pump directly from the boiler by a 4-inch pipe reduced 1½ inches, and the lift is 65 feet. The pump is operated twelve hours each day, having an actual capacity of 500 gallons per minute, or 1.11 second-feet, and is expected to irrigate 125 acres. So far only 50 acres have been watered. The land is planted in grapes, corn, sorghum, alfalfa, and tomatoes. The water is carried to the land in a 12-inch iron pipe, 2,000 feet long, with outlets at intervals, thus avoiding waste by seepage. The intention is to put in a pump which will utilize more or all of the power as soon as the agricultural situation warrants it. Another pumping plant owned by J. S. Taylor, a successful grape grower, is reported as consisting of two 80-horsepower boilers and a pump having a capacity of 1,250 gallons per minute. E. T. Lamphere has a 10-horsepower Weber gasoline engine with a triplex Van Wie pump, raising 300 gallons of water per minute. Attention is given to this about once in six or eight hours, and at one time during the summer, under pressure, the pump was operated continuously four days and nights, stopping only to oil the machinery.

Three miles from Laredo, L. D. Sterneberg has a windmill by which he pumps from the river when there is sufficient wind, irrigating 3 acres, except in the months of October and November. The cost of his outfit was $220. Three miles north of Laredo, C. A. Charleston has had better success with windmill irrigation than anyone else in that section. He uses a 12-foot wheel and pumps from a 30-foot well into a reservoir of 5,000 gallons capacity, irrigating about 5 acres. The total cost of the plant was $425. He finds his present reservoir too small and is building one of 300,000 gallons, or 0.92 acre-foot, capacity.

At Hidalgo, down toward the mouth of the Rio Grande, is a steam-

pumping plant owned by Closner & Lipscomb. It consists of a 25-horsepower engine operating a centrifugal pump with a capacity of 4,750 gallons per minute, or 10.58 second-feet. The water is pumped from the Rio Grande and is used for irrigating 100 acres in sugar cane and corn.

In the vicinity of Brownsville, near the mouth of the Rio Grande, there has been considerable interest shown in irrigation by pumping. The plant of Rabb & Stark, located 6 miles east of Brownsville, on the river, was built in 1891, and consists of a 50-horsepower boiler and a 40-horsepower engine operating a Menge pump with a theoretical capacity of 9,000 gallons per minute, or 20 second-feet. The average lift is 18 feet, and the pump is run about twelve hours each day during the irrigation season. There is no reservoir used, the water being pumped directly into the ditches. The estimated cost of the plant is $2,000, and it irrigates 200 acres in sugar cane, cotton, and corn.

George Brulay, of Brownsville, also has a pumping plant worthy of attention. It is located 8 miles below Brownsville, in Cameron County, and was completed and first used in 1896. It consists of two boilers having an aggregate capacity of 100 horsepower and a 45-horsepower Morris centrifugal pump with a maximum pumping capacity of 8,000 gallons per minute, or 17.82 second-feet. The total lift required is 22 feet, and the pump is run about fourteen hours per day when used. It is designed to cover 300 acres, but so far only 200 acres planted in sugar cane have been irrigated.

E. H. Goodrich reports having put in a 10-horsepower Priestman engine on a resaca on his place, 6 miles north of Brownsville, in March, 1897, but has used it very little, owing to the favorable weather and the ditches not being finished. With two 12-foot windmills on the same place he irrigated last year about 35 acres in corn, cotton, and garden truck. He has also irrigated between 15 and 18 acres on his place 3 miles north of Brownsville with a 14-foot windmill, pumping from a well dug on the bank of a resaca. The distance to the water varies from 5 to 12 feet, and the pumps, which are three in number, empty into a flume connecting directly with the ditches. He is confident that he could have accomplished much more with the windmills if he had used a reservoir. The total cost of the last-named plant was $300.

LLANO ESTACADO.

The arid portion of Texas, or that part with an average annual rainfall of less than 20 inches, consists principally of the Llano Estacado and Trans-Pecos regions. These differ so widely in topography and climate that they should be discussed separately. The Llano Estacado has been described as a great plateau having an area of about 36,000 square miles and with an almost perfectly flat surface, which rises gradually toward the northwest. No rivers cross its surface and

at only a few widely scattered localities, and for short distances, is flowing water to be found. The soil is of such character that it readily drinks in the rain which falls upon it. This water, or that part of it which is not soon evaporated, percolates downward and is reached by wells of from 40 to 200 feet in depth. Many of these wells are capable of furnishing a supply almost inexhaustible to ordinary means of pumping. The soil is too dry to be successfully cultivated without irrigation, and this can be practiced, if at all, only by means of water raised by pumps. Pumping is most cheaply accomplished by means of windmills, these being particularly successful owing to the almost constant winds that sweep across the plains.

Windmills have been used for many years to furnish water for stock purposes, and they have been tried successfully on a small scale for irrigation. The settlers of this region have learned to appreciate the value and limitations of devices of this character for raising water. Reservoirs or tanks are almost always used in connection with the mills. These are made by scraping away the surface soil and piling it in a continuous wall, forming banks from 4 to 6 feet high. The sides and bottom are made impervious by turning in a little water at a time and puddling the soil by driving horses or cattle about in it for a day or more. The following instances illustrate the progress within this area:

About the center of the Llano Estacado, in Hale County, T. W. Morrison owns a plant consisting of two aermotor wheels, 8 and 12 feet in diameter, respectively, pumping from wells 50 feet deep, with water at 20 feet below the surface. Each windmill lifts the water 35 feet. One wheel is used for supplying the residence; the other pumps into a reservoir 125 feet long and 100 feet wide and 4 feet deep. This irrigates from 5 to 6 acres, besides furnishing water for the stock. His wheels have been in use since 1891. J. H. Wayland, of the same county, has three aermotors pumping from wells 35 to 60 feet deep into a reservoir 300 feet long, 75 feet wide, and 6 feet deep, and expects to irrigate 25 acres, of which 15 were irrigated in 1896. The total cost of the wells, pumps, wheels, and reservoir was $505. The total cost of the plant, which must include land and fencing, is given as $1,000. Southeasterly from here, at Emma, in Crosby County, J. W. Murray has an 8-foot windmill pumping from a well 174 feet deep, with water at 124 feet. He pumps into barrels, from which he irrigates about 1½ acres. The total cost was $222.

Along the Texas and Pacific Railroad, especially at Midland and Marienfeld, there has been considerable interest taken in this form of irrigation. It is claimed by a man of experience—A. Rawlins—that two 8-foot aermotors, pumping from wells 40 feet deep, with water sufficient to keep a 4-inch pump running into a tank 100 feet square, with a 6-foot bank, will give sufficient water to irrigate 10 acres in fruits and vines the first year, 12 acres the second year, and

15 acres the third. Grain and garden vegetables, which require more water, will cut down the average. Fifteen head of horses will puddle a tank satisfactorily. He is irrigating 10 acres in cotton with two 12-foot aermotors, pumping from wells 125 feet deep into a tank 65 feet square.

This region is so sparsely settled and accessible with such difficulty that it has not been practicable to obtain full information concerning the small irrigating plants scattered here and there. Sufficient has been learned, however, to justify the belief that this method of agriculture is becoming a more and more important factor in the development of this area, reducing the cost of supplies, and thus aiding in the main industry, that of cattle raising.

Willard D. Johnson, hydrographer of the United States Geological Survey, states that at not more than half a dozen places in the Panhandle, probably, is there irrigation, from a single plant, of more than a small garden patch, and that of these but two show any development worth mentioning. These two are headquarter ranches of large cattle companies. At the majority of such cattle-ranch headquarters, however, there is absolute barrenness. The exceptions are the "L. E." ranch, on Romero Creek, a small spring-fed tributary of the Canadian from the north, and a ranch on Adobe Wall Creek, another spring-fed tributary of the Canadian from the north. As a result of irrigation, practically from springs, these two large ranches are able to supply themselves with a variety of vegetables and fruits, and in addition grow several hundred acres of alfalfa and other forage crops.

At the "L. E." ranch the garden produces much more abundantly than is demanded for the needs of the ranch, and much of this extra produce is given away to neighbors. The fruit trees which bear successfully are the apple, pear, peach, apricot, nectarine, plum, and cherry. Of shade trees about the house there are locust, ash, willow, osage orange, and cottonwood. There is also a vineyard yielding several varieties of excellent grapes. This ranch was visited by Mr. Johnson. The other ranch, not visited, is reported to have more alfalfa and about an equal display of garden produce. Each of these ranches is located below the edge of the plains, in the little valley of a spring creek of which it uses all the water. More can be done in each case by storage, which, in fact, is contemplated in the case of the "L. E." ranch. The great "X. I. T." company does a little in irrigation at several of its headquarter ranches, but much less than might easily be accomplished.

The two garden spots referred to are notable object lessons to the whole of the Panhandle. Spring creeks in the region are not numerous, but only in these two cases have they been fully utilized, and the examples thus set are destined to be rapidly imitated.

Of the future of irrigation here in general, it may be said that there is opportunity for but the little indicated, at these widely scattered

spots, but that this little will prove to be just that small amount needed for rendering practicable the utilization of the high plains for stock raising, under conditions that will be bearable for those who have to live upon these great pasture lands for the conduct of the stock industry.

PECOS VALLEY.

Pecos River rises in the northeastern portion of New Mexico and flows in a general southerly course through the southeastern part of that Territory, crossing the western prolongation of Texas and finally entering the Rio Grande at about the lower third of the length of that

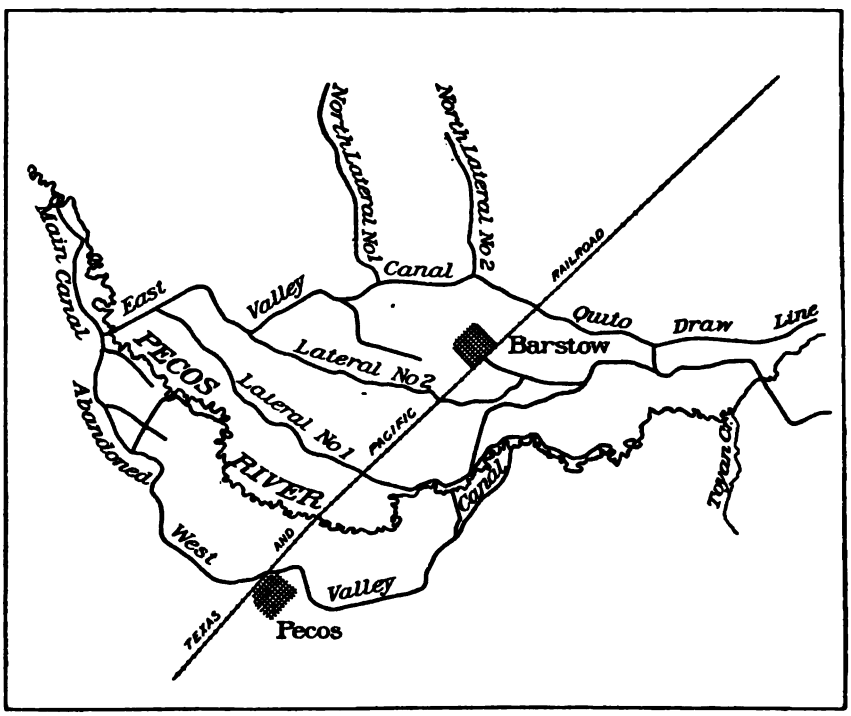


FIG. 12.—Map showing location of Margueretta Canal.

stream. It is supplied to a considerable extent by water from large springs which issue from the limestone rocks of the region, of which Roswell is now the principal town. These maintain the perennial flow of the river, the run-off from the catchment basin being irregular in character and shrinking at times to relatively small amounts. Large irrigation works have been constructed in the vicinity of Roswell and at points below, utilizing the greater part of the summer flow of the river, so that during the dry season of the year little water crosses the Texas line. That which does flow in the stream is largely derived from the seepage of irrigated lands above and is heavily charged with alkaline salts. Irrigation canals have, however, been constructed

FLUME ACROSS PECOS RIVER.

along the valley in Texas, principally near the town of Pecos, at the crossing of the Texas and Pacific Railroad. The valley is fertile, and where properly irrigated large crops are produced.

The most important irrigation system along the river in Texas is the one nearest the New Mexico line, known as the Margueretta Canal. This was begun in 1887 by the Pioneer Canal Company, afterwards consolidated with the Margueretta Canal Company, which now owns the whole system. Water is diverted by means of a brush dam, it being deemed impracticable to build a masonry structure in the sandy river bid. The dam is 90 feet long and 5 feet high. The canal is built, as shown in fig. 12, on the western side of the river for 3 miles, then crosses the stream on a flume (shown in Pl. VIII), and runs in a general easterly direction for 12 miles. There is also a branch continuing down the west bank for a considerable distance, being the main part of the old Pioneer Canal; but this has been abandoned, there being no farms in cultivation for more than a mile or so below the flume. The dimensions of the main ditch are: top width, 30 feet; bottom width, 18 feet; depth of water, 4½ feet. There are three principal laterals, with a bottom width of 12, 6, and 8 feet, respectively.

The canal was first used in 1889, and the extent of land irrigated by it is steadily increasing. The total cost of the system was over $150,000, and the acreage it is designed to cover is about 40,000, only 6,000 of which are as yet under cultivation. The water rights are sold at $10 per acre, a permanent right guaranteeing 25 inches of water to the acre. The annual rental is $1 and $1.50 for each acre served with water. The principal crop is cotton, of which there are about 3,500 acres. The other crops cultivated are alfalfa, sugar beets, and all kinds of forage plants, fruits, and vegetables.

Sugar beets tested in 1896 showed between 14 and 20 per cent of saccharine matter. Peaches, apples, and grapes do well. Cotton averages 500 pounds of lint to the acre. The annual rainfall is about 12 inches. Owing to the high elevation (2,700 feet) the seasons are much later than in most of the irrigated parts of the State. The enterprise seems to have been conducted with energy and care, the canals and head gates are well planned and well built, and all together the scene about Barstow, the center of the irrigated portion, has a general air of healthy growth and prosperity that is very pleasing to the eye after the many miles of desert scenery between it and El Paso. There are, however, a number of problems that must be solved before agriculture will be successful in all places. Much of the land is impregnated with what is known as alkali. At first this does not prove troublesome, but after a few years of cultivation it may be brought to the surface by injudicious treatment. The river water used in irrigation continually adds to the supply of this mineral matter. The only remedy so far applied is drainage, this being as important in its way as irrigation. The land is very nearly level, and considerable

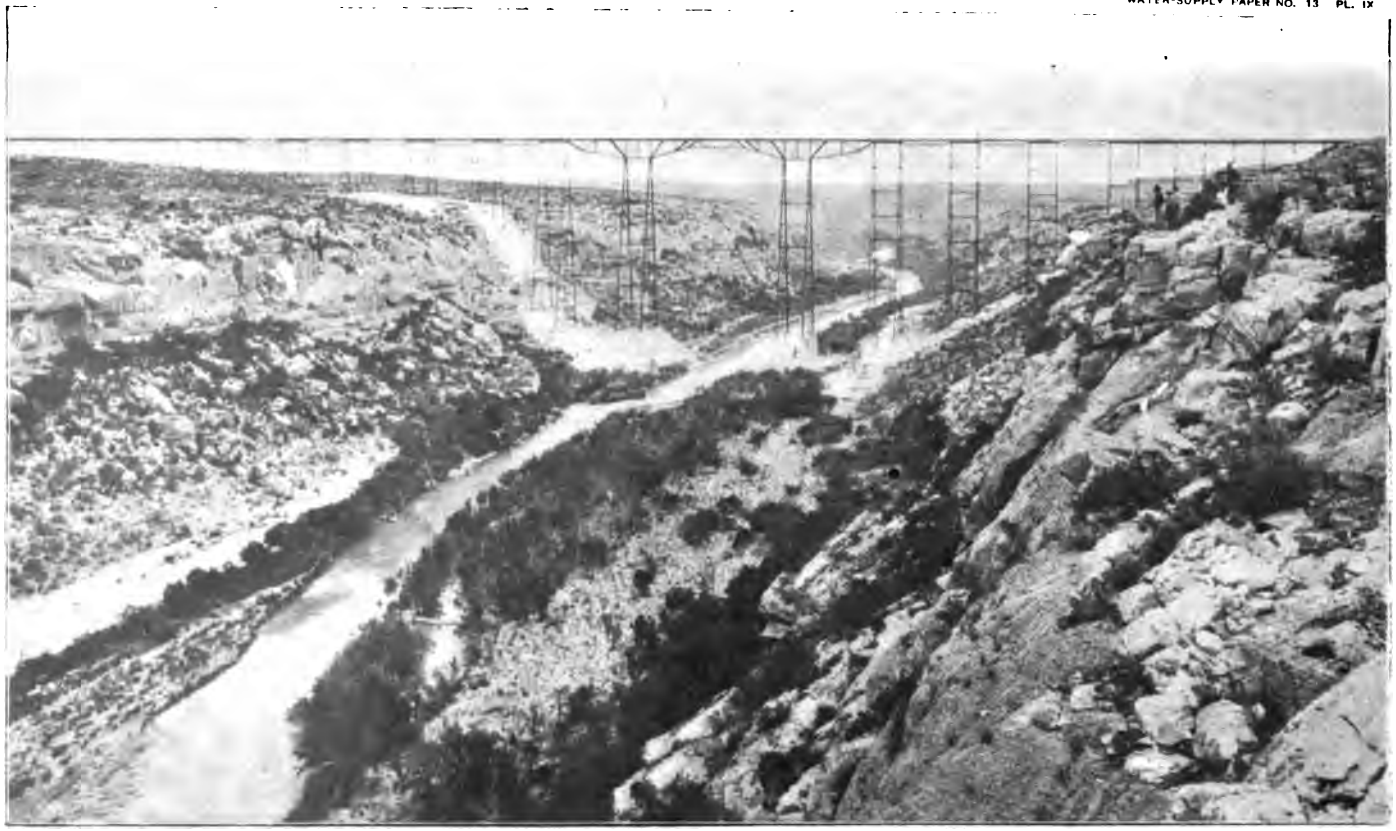
care will be required to provide means by which the accumulated alkali can be washed from the soil. One of the principal crops is alfalfa, which sells at $8 per ton on the cars at Pecos and at $10 per ton retail.

Flowing wells have been obtained in this valley near the town of Pecos. Most of this water contains mineral matter in solution, sulphur being especially noticeable. The water from the wells is used for domestic purposes and also for irrigating kitchen gardens and fruit and shade trees.

About 28 miles below Pecos is the canal of the Pecos River Irrigation Company, on the west side of the river, running in a general southeasterly direction for 12 miles. It is the oldest ditch on the river in Texas, having been built in 1875 and 1876. It was enlarged in 1889 and used again in 1890, but has never been entirely completed in its enlarged condition. It takes its water by means of a brush-and-stone dam about 60 feet long and 5 to 6 feet high. The total cost of the undertaking is given as about $35,000, and the cost of the water rights as from $2.50 to $5 per acre, with an annual assessment of 50 cents per acre. It is designed to irrigate 20,000 acres, but only 600 were irrigated in 1896. There is complaint that the water supply was very short for several years, especially in 1892, 1893, and 1894, just after the dam at Eddy, New Mexico, was completed. The flow has increased since then, but the river becomes quite low and the water bitter in March and April of each year. On this account it is fortunate that the season is so late here that cotton is not planted before April 15, corn about May 15, and alfalfa in June. The soils and crops raised on them are similar to those at Pecos and Barstow.

The Grand Falls Irrigation and Improvement Company takes out a canal 4 miles below the headgates of the one just discussed, but on the opposite side of the river. It was begun in 1896 and is finished for 16 miles; it is supplied by a brush-and-stone dam across the river, 100 feet long and 7 feet high. The water rights are valued at $15 per acre and the annual assessment is $1.25 per acre.

On Comanche Creek, near Fort Stockton, in Pecos County, are two farms irrigated from ditches. That of the Southwestern Irrigation Company is nearest the head of the creek; it is on the east side, 6 miles in length, with top width of 7 feet, bottom width 6 feet, and depth of water 2½ feet. It is filled by means of a loose-rock dam 20 feet long and 6 feet high. More than 1,000 acres have been cultivated, though only 400 were tilled in 1896. The principal crops were alfalfa and corn. The 200 acres in alfalfa gave an average of 5 tons to the acre, the alfalfa being cut five times. Corn yielded 25 bushels to the acre. The lands are cultivated entirely by the company owning the canal. The only other ditch of importance is that of the Rooney Irrigation Company. It runs on the west side of the creek for a distance of 7 miles, its dimensions being 12 feet wide on top, 8



PECOS CANYON AT SOUTHERN PACIFIC RAILWAY BRIDGE.

feet wide on bottom, and having water 3 feet in depth. It was built in 1875 and commands 1,200 acres, of which 1,000 were irrigated in 1896. The principal crops were corn, wheat, oats, cotton, and alfalfa.

At the lower end of its course Pecos River flows through a narrow canyon, illustrated on Pl. IX, taken from Part II of the Eighteenth Annual Report[1] of this Survey. This shows the new bridge of the Southern Pacific Railroad crossing 10 miles above the Rio Grande.

TRANS-PECOS TEXAS.

That portion of the State west of Pecos River is commonly known as Trans-Pecos Texas. It is a peculiar country, rough and mountainous, with no perennial streams. The storm waters rush out upon the lowlands and are rapidly absorbed in the sandy plains, from which the mountains rise abruptly as isolated peaks or ranges. The soil of these plains is of remarkable fertility and when watered produces abundantly. Irrigation, however, is practicable only by means of storage reservoirs holding the storm waters. Such reservoir sites occur in many places, and several of them have been mapped by the topographers of the Geological Survey.

Trans-Pecos Texas is bounded on the west and south by the Rio Grande, from which water is taken for irrigation mainly in the vicinity of El Paso. There are, however, a few tracks watered by small lost streams, there being in particular about 75 acres irrigated from Lympia Creek.

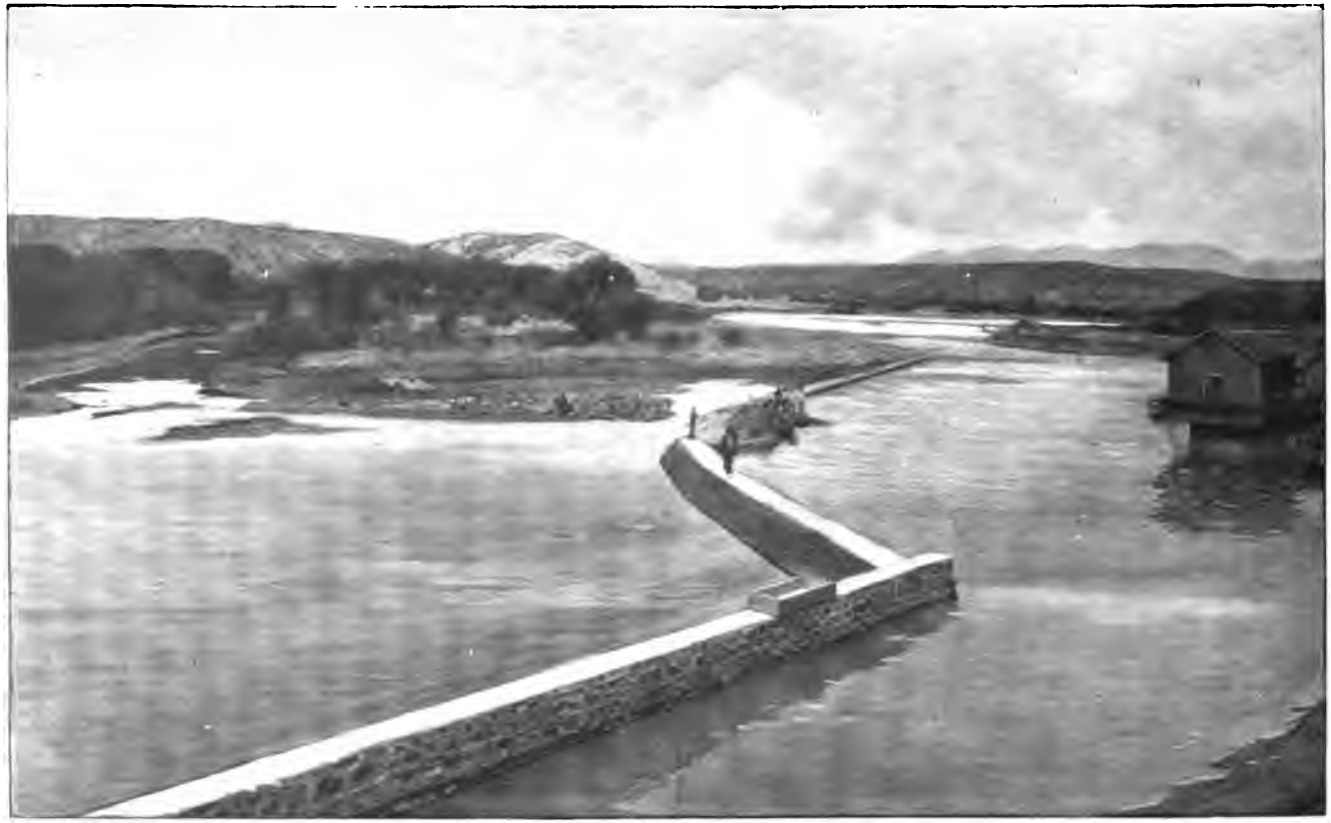
At El Paso the principal canal is that owned by the El Paso Irrigation Company. It was begun in 1889 and completed in 1891. Later the affairs of the company were put into the hands of a receiver, and the property was bought at receiver's sale by Thomas Worthington, of Manchester, England, the trustee for the bondholders. It begins 1 mile northwest of the town of El Paso and runs in a generally southeastern direction for 30 miles. At the beginning its width is 30 feet, but it gradually diminishes to 15 feet at Fabens, where it returns to the Rio Grande. Water is diverted by a masonry wing dam, extending diagonally up the river for about 300 feet and about half way across, as shown in Pl. X. The original cost was approximately $150,000, and some $70,000 has since been expended for protection from overflows and for repairs. The water rights under the new management have not yet been issued. The yearly water rental is $2 per acre. The canal was designed to cover 30,000 acres; 3,000 were irrigated from it during 1896.

There are three old Mexican ditches taken from the Rio Grande below El Paso on the American side, at Ysleta, Socorro, and San Elizario, irrigating from 1,000 to 1,200 acres each. The total area watered in the county is estimated at 8,000 acres. Irrigation has been practiced

[1] Geology of the Edwards Plateau and Rio Grande Plain, adjacent to Austin and San Antonio, Texas, etc., by Robert T. Hill and T. Wayland Vaughan, Pl. XXV, p. 208.

here probably longer than in any other part of the United States. The old Spanish records say that when this pass of the river was first reached by the exploring party of Coronado, villages of Indians were found on the Mexican side on the site of the present town of Juarez and on the American side at Ysleta and below. These Indians had a system of irrigation of seemingly great antiquity, which has been continued and carried on by the descendants of the aborigines and those of their conquerors continuously for three hundred and fifty years.

During the spring of 1897 the large canal was damaged by the flood that submerged so much of the town of El Paso. This flood reached its height on May 26 and quickly subsided. The banks were badly cut and the canal was completely obliterated in some places. The truck gardens and orchards near the city were flooded and damaged, a layer of mud about 3 inches thick being deposited over the surface. It was noticeable that while most trees withstood the flooding comparatively well, the peach trees were almost uniformly killed. Fortunately for the farmers lower down, a portion of the river cut for itself a fresh channel, curving inward, crossing the canal, and then recrossing it at the last point at which the banks were damaged. In this way they have been supplied with water and are able to save their crops, which otherwise would have been ruined.



WING DAM OF EL PASO IRRIGATION COMPANY; LOOKING UPSTREAM.

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1895.

Sixteenth Annual Report of the United States Geological Survey, 1894–95, Part II, Papers of an economic character, 1895, octavo, 598 pp.

Contains a paper on the public lands and their water supply, by F. H. Newell, illustrated by a large map showing the relative extent and location of the vacant public lands; also a report on the water resources of a portion of the Great Plains, by Robert Hay.

A geological reconnoissance of northwestern Wyoming, by George H. Eldridge, 1894; octavo, 72 pp. Bulletin No. 119 of the United States Geological Survey; price, 10 cents.

Contains a description of the geologic structure of portions of the Big Horn Range and Big Horn Basin, especially with reference to the coal fields, and remarks upon the water supply and agricultural possibilities.

Report of progress of the division of hydrography for the calendar year 1893–94, by F. H. Newell, 1895; octavo, 176 pp. Bulletin No. 131 of the United States Geological Survey; price, 15 cents.

Contains results of stream measurements at various points, mainly within the arid region, and records of wells in a number of counties in western Nebraska, western Kansas, and eastern Colorado.

1896.

Seventeenth Annual Report of the United States Geological Survey, 1895–96, Part II, Economic geology and hydrography, 1896; octavo, 864 pp.

Contains papers on "The underground water of the Arkansas Valley in eastern Colorado," by G. K. Gilbert; "The water resources of Illinois," by Frank Leverett; and "Preliminary report on the artesian waters of a portion of the Dakotas," by N. H. Darton.

Artesian-well prospects in the Atlantic Coastal Plain region, by N. H. Darton, 1896; octavo, 230 pp., 19 plates. Bulletin No. 138 of the United States Geological Survey; price, 20 cents.

Gives a description of the geologic conditions of the coastal region from Long Island, N. Y., to Georgia, and contains data relating to many of the deep wells.

Report of progress of the division of hydrography for the calendar year 1895, by F. H. Newell, hydrographer in charge, 1896; octavo, 356 pp. Bulletin No. 140 of the United States Geological Survey; price, 25 cents.

Contains a description of the instruments and methods employed in measuring streams and the results of hydrographic investigations in various parts of the United States.

1897.

Eighteenth Annual Report of the United States Geological Survey, 1896–97, Part IV, Hydrography, 1897; octavo, 756 pp.

Contains a "Report of progress of stream measurements for the calendar year 1896," by Arthur P. Davis; "The water resources of Indiana and Ohio," by Frank Leverett; "New developments in well boring and irrigation in South Dakota," by N. H. Darton; and "Reservoirs for irrigation," by J. D. Schuyler.

Water Supply and Irrigation Papers.

This series of papers is designed to present in pamphlet form the results of stream measurements and of special investigations. A list of these, with other information, is given on the outside (or fourth) page of this cover.

Survey bulletins can be obtained only by prepayment of cost, as noted above. Postage stamps, checks, and drafts can not be accepted. Money should be transmitted by postal money order or express order, made payable to the Director of the United States Geological Survey. Correspondence relating to the publications of the Survey should be addressed to **The Director, United States Geological Survey, Washington, D. C.**

WATER-SUPPLY AND IRRIGATION PAPERS.

1. Pumping water for irrigation, by Herbert M. Wilson, 1896.
2. Irrigation near Phœnix, Arizona, by Arthur P. Davis, 1897.
3. Sewage irrigation, by George W. Rafter, 1897.
4. A reconnoissance in southeastern Washington, by Israel C. Russell, 1897.
5. Irrigation practice on the Great Plains, by E. B. Cowgill, 1897.
6. Underground waters of southwestern Kansas, by Erasmus Haworth, 1897.
7. Seepage waters of northern Utah, by Samuel Fortier, 1897.
8. Windmills for irrigation, by E. C. Murphy, 1897.
9. Irrigation near Greeley, Colorado, by David Boyd, 1897.
10. Irrigation in Mesilla Valley, New Mexico, by F. C. Barker, 1898.
11. River heights for 1896, by Arthur P. Davis, 1897.
12. Water resources of southeastern Nebraska, by Nelson Horatio Darton, 1898.
13. Irrigation systems in Texas by W. F. Hutson, 1898.
15. Operations at river stations, 1897, Part I, 1898.
16. Operations at river stations, 1897, Part II, 1898.

In press:

14. New tests of certain pumps and water lifts used in irrigation, by O. P. Hood, 1898.

In addition to the above, there are in various stages of preparation other papers relating to the measurement of streams, the storage of water, the amount available from underground sources, the efficiency of windmills, the cost of pumping, and other details relating to the methods of utilizing the water resources of the country. Provision has been made for printing these by the following clause in the sundry civil act making appropriations for the year 1896–97:

Provided, That hereafter the reports of the Geological Survey in relation to the gauging of streams and to the methods of utilizing the water resources may be printed in octavo form, not to exceed 100 pages in length and 5,000 copies in number; 1,000 copies of which shall be for the official use of the Geological Survey, 1,500 copies shall be delivered to the Senate, and 2,500 copies shall be delivered to the House of Representatives, for distribution. [Approved June 11, 1896; Stat. L., vol. 29, p. 453.]

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IRRIGATION REPORTS.

The following list contains the titles and brief descriptions of the principal reports elating to water supply and irrigation prepared by the United States Geological Survey since 1890:

1890.

First Annual Report of the United States Irrigation Survey, 1890; octavo, 123 pp.

Printed as Part II, Irrigation, of the Tenth Annual Report of the United States Geological Survey, 1888-89. Contains a statement of the origin of the Irrigation Survey, a preliminary report on the organization and prosecution of the survey of the arid lands for purposes of irrigation, and report of work done during 1890.

1891.

Second Annual Report of the United States Irrigation Survey, 1891; octavo, 395 pp.

Published as Part II, Irrigation, of the Eleventh Annual Report of the United States Geological Survey, 1889-90. Contains a description of the hydrography of the arid region and of the engineering operations carried on by the Irrigation Survey during 1890; also the statement of the Director of the Survey to the House Committee on Irrigation, and other papers, including a bibliography of irrigation literature. Illustrated by 29 plates and 4 figures.

Third Annual Report of the United States Irrigation Survey, 1891; octavo, 576 pp.

Printed as Part II of the Twelfth Annual Report of the United States Geological Survey, 1890-91. Contains "Report upon the location and survey of reservoir sites during the fiscal year ended June 30, 1891," by A. H. Thompson; "Hydrography of the arid regions," by F. H. Newell; and "Irrigation in India," by Herbert M. Wilson. Illustrated by 93 plates and 190 figures.

Bulletins of the Eleventh Census of the United States upon irrigation, prepared by F. H. Newell; quarto.

No. 35, Irrigation in Arizona; No. 60, Irrigation in New Mexico; No. 85, Irrigation in Utah; No. 107, Irrigation in Wyoming; No. 153, Irrigation in Montana; No. 157, Irrigation in Idaho; No. 163, Irrigation in Nevada; No. 178, Irrigation in Oregon; No. 193, Artesian wells for irrigation; No. 198, Irrigation in Washington.

1892.

Irrigation of western United States, by F. H. Newell; extra census bulletin No. 23, September 9, 1892; quarto, 22 pp.

Contains tabulations showing the total number, average size, etc., of irrigated holdings, the total area and average size of irrigated farms in the subhumid regions, the percentage of number of farms irrigated, character of crops, value of irrigated lands, the average cost of irrigation, the investment and profits, together with a résumé of the water supply and a description of irrigationby artesian wells. Illustrated by colored maps showing the location and relative extent of the irrigated areas.

1893.

Thirteenth Annual Report of the United States Geological Survey, 1891-92, Part III, Irrigation, 1893; octavo, 486 pp.

Consists of three papers: "Water supply for irrigation," by F. H. Newell; "American engineering" and "Engineering results of the Irrigation Survey," by Herbert M. Wilson; and "Construction of topographic maps and selection and survey of reservoir sites," by A. H. Thompson. Illustrated by 77 plates and 119 figures.

A geological reconnoissance in central Washington, by Israel Cook Russell, 1893; octavo, 108 pp., 15 plates. Bulletin No. 108 of the United States Geological Survey; price, 15 cents.

Contains a description of the examination of the geologic structure in and adjacent to the drainage basin of Yakima River and the great plains of the Columbia to the east of this area, with special reference to the occurrence of artesian waters.

1894.

Report on agriculture by irrigation in the western part of the United States at the Eleventh Census, 1890, by F. H. Newell, 1894; quarto, 283 pp.

Consists of a general description of the condition of irrigation in the United States, the area irrigated, cost of works, their value and profits; also describes the water supply, the value of water, of artesian wells, reservoirs, and other details; then takes up each State and Territory in order, giving a general description of the condition of agriculture by irrigation, and discusses the physical conditions and local peculiarities in each county.

Fourteenth Annual Report of the United States Geological Survey, 1892-93, in two parts; Part II, Accompanying papers, 1894; octavo, 597 pp.

Contains papers on "Potable waters of the eastern United States," by W J McGee; "Natural mineral waters of the United States," by A C. Peale; and "Results of stream measurements," by F. H Newell. Illustrated by maps and diagrams.

(Continued on third page of cover.)

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

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IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

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UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

NEW TESTS

OF

CERTAIN PUMPS AND WATER LIFTS USED IN IRRIGATION

BY

OZNI PORTER HOOD

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1898

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, January 24, 1898.

SIR: I have the honor to transmit herewith a paper entitled New Tests of Certain Pumps and Water Lifts Used in Irrigation, by Ozni P. Hood, professor of mechanics and engineering at the State Agricultural College, Manhattan, Kansas, and to recommend that it be published in the series of Water-Supply and Irrigation Papers. The facts herein briefly set forth represent a large body of original experimental work by Professor Hood and assistants. begun in the summer of 1896 and but recently brought to a finish.

While the water lifts have had their origin in the needs of irrigation, devices for pumping have not; with them, indeed, there is no special adaptation to irrigation use. Economy of power must be the essence of such adaptation; time is not, for ample time can be taken to secure the full supply. But with existing designs, as, for example, the deep-mine varieties, the aim usually has been rather to attain rapidity of delivery, even at the cost of wasteful expenditure of power. Among appliances for irrigation, pumps, of whatever kind, are but in a trial stage. Their wide use and the extension of irrigation possibilities that would result can come only through adaptations in design especially economical of power. It should not be left to come by gradual evolution through chance suggestions of practice, but should be deliberately brought about by engineers. Professor Hood's experimental determinations of efficiencies and of the little sources of frictional loss have contributed data which will be useful for this purpose.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

NEW TESTS OF CERTAIN PUMPS AND WATER LIFTS USED IN IRRIGATION.

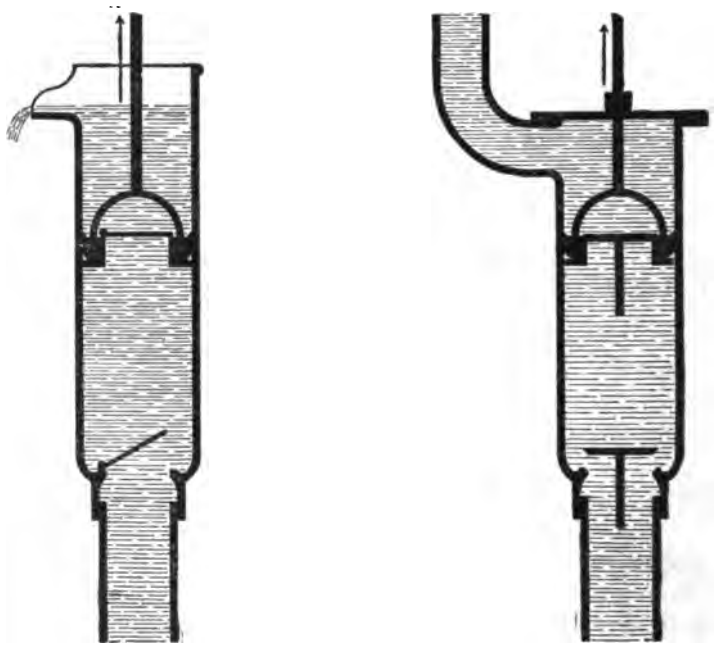
By O. P. Hood.

INTRODUCTION.

The necessity of raising water for irrigation and other purposes has been met by a great variety of water-lifting devices. By far the most familiar of these is the reciprocating pump, ranging in capacity from the simple mechanism for cisterns to the large engines used for public water supply. In order that one may know what it is reasonable to expect from the many forms of pumps, and be able to make an intelligent selection, it is necessary first to become acquainted with some of the problems connected with their design and operation. In this paper it is the author's purpose to state certain of these problems, to give the results of new tests of irrigation pumps and machinery, and to offer notes on several other water lifts in less common use.

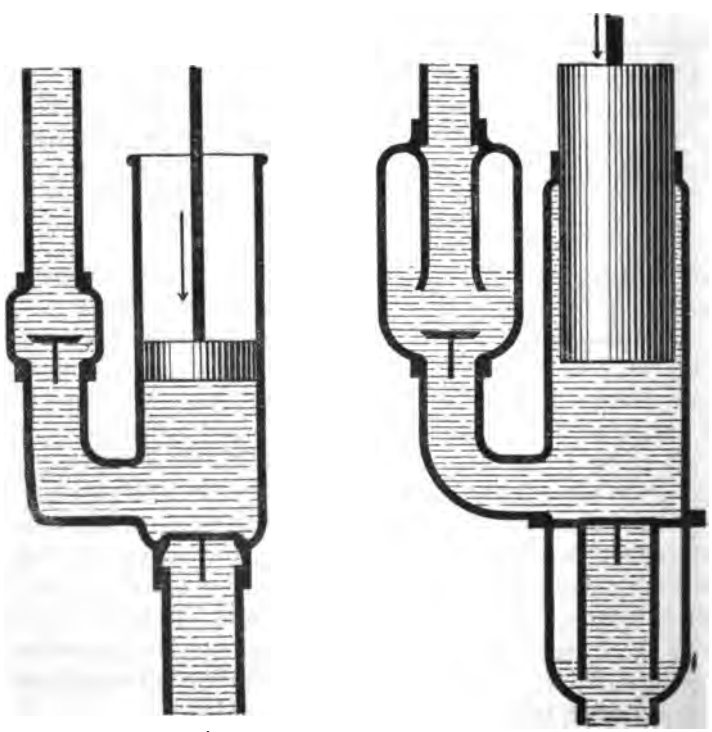
DEFINITIONS.

Of reciprocating pumps there are many forms, and among them there are essential differences. The names commonly used to designate these diverse forms are not in every case self-explanatory; in some cases they may be even misleading. Among these common designations are bucket pump, lift pump, suction pump, combined suction and lift pump, piston pump, plunger pump, and force pump. Common to all these forms is a backward and forward moving piston or plunger. When all the effective work is done while the piston is moving either in one direction or the other the pump is single-acting. When the effective work is distributed between the two motions the pump is double-acting. It is to this alternating movement that the term "reciprocating" applies. Generally speaking, in all reciprocating pumps there are three essential parts—the suction pipe below, the discharge pipe above, and, intermediate in position between these two, the pump cylinder, in which a piston reciprocates.



A *B*

FIG. 1.—Vertical sections of bucket pump. *A*, ordinary form; *B*, with stuffing box.

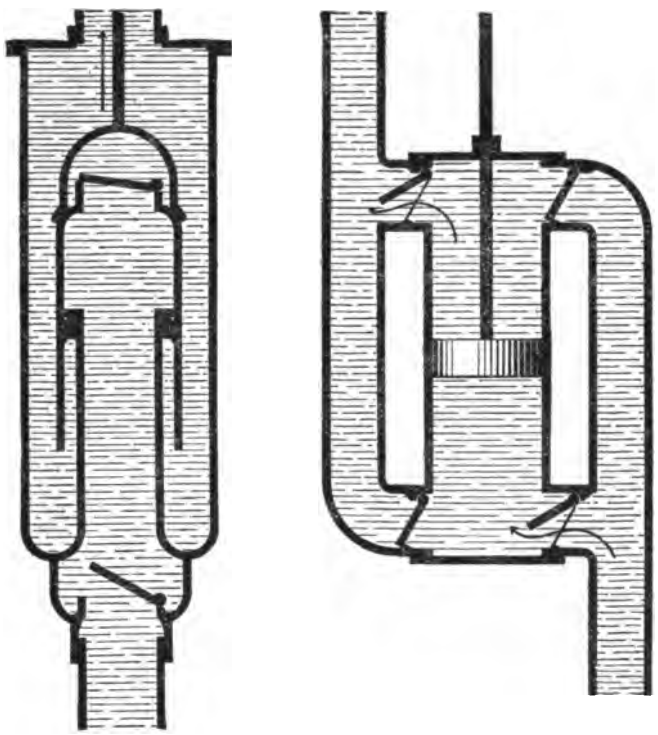


A *B*

FIG. 2.—Vertical sections of piston and plunger pumps. *A*, piston pump; *B*, plunger pump.

A bucket pump is one in which the reciprocating piston has a valve-covered opening through it. Such a pump is shown diagrammatically in fig. 1, *A*. Between the incoming water and the piston is another valve-covered opening.

If the pump parts are so placed that the suction valve comes below the normal water level, it is called a lift pump. If, on the other hand, the suction lift is relatively great and the delivery pipe short, it is called a suction pump. Most pumps, however, by reason of the more even proportioning of these parts, are called combined suction and



A *B*

FIG. 3.—Vertical sections of plunger and double-acting pumps. *A*, plunger pump with large valve openings; *B*, double-acting pump.

lift pumps. Fig. 1, *B*, shows a pump in which the pump rod is carried through a stuffing box, whereby it is rendered unnecessary for the delivery pipe to follow the pump rod. A piston pump is one in which the piston carries no valve, the discharge valve being otherwise placed, as in fig. 2, *A*. Fig. 2, *B*, shows a plunger pump, a solid plunger, packed on the outside, replacing the piston, which is packed on the inside. Fig. 3, *A*, indicates one of several methods of obtaining large valve openings. Fig. 3, *B*, shows a double-acting pump, serving as a suction and force pump and acting in either direction of movement of the piston. For irrigation the type most in favor is that shown in fig 1, *A*, operated as a simple lift pump.

SUCTION.

Whenever, within a closed vessel, the normal air pressure is by any means diminished, there results what is commonly called suction. Suction is here but a manifestation of superior pressure on the part of the external air. This atmospheric pressure, though varying continually, is, at sea level, about 14.7 pounds per square inch. A column of water about 34 feet in height exerts an equal pressure. Hence, to raise the piston, shown in fig. 4, it is necessary not only to lift the column of water, L, already above the piston, but to overcome as well the atmospheric pressure, equivalent to an additional column of water, B, 34 feet in height; or to overcome, in total, a pressure equivalent to the weight of a column of water, L+B.

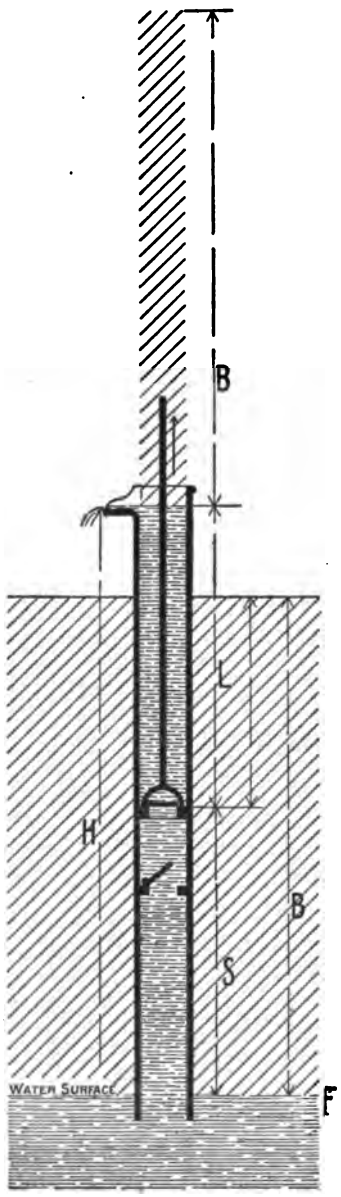


FIG. 4.—Diagrammatic representation of pump problem.

But with the raising of the piston conditions for suction, so called, are thereby at the same time established, i. e., the water surface in the pump tube below the piston is relieved of pressure, whereas outside the tube the atmospheric pressure continues, undisturbed, upon the surrounding water surface. It results that, by reason of this pressure without, water is forced upward in the pump tube; and it continues to follow the piston to a balancing height, which at sea level, as stated, is 34 feet. If the lift of the piston is short of this height the rising water will bear upward against the under side of the piston with a pressure equivalent to the weight of so much of the column as remains, or B—S; less, however, such force as may be used up in overcoming the various resistances during motion. As the piston lift does in fact always stop short of this maximum, the remnant of pressure, B—S, serves as a head of water for effecting flow into the suction pipe and for filling the cylinder. Though the theoretical limit to the height of suction is

about 34 feet, a practical limit is reached at from 25 to 30 feet, depending on the perfection of packing, the tightness of joints, and the piston speed. If, however, the piston speed be too great, the head of water (B—S) may not be able to produce a flow sufficiently rapid to follow it, and in consequence there will be incomplete filling of the cylinder during the period of the upstroke.

The water will encounter resistances to flow in the suction pipe, such as those involved in friction against its sides, in lifting the suction valve, and in passing through the reduced valve opening, all of which resistances will tend to diminish its velocity of entry into the cylinder. The less the height of the suction lift the greater will be the head left for overcoming these resistances, thereby admitting of a more rapid rate of filling and a higher piston speed. Again, by enlarging the suction pipe and thereby reducing the sum of the frictional resistances the flow will be increased. It follows that in practice many pumps have suction pipes of larger diameter than their discharge pipes.

The height of suction lift limits the possible piston speed. To show this, a 4-inch by 14-inch pump was arranged to discharge water at a total height of 38 feet, the cylinder being placed successively at various heights in the pipe, from the natural water level up to the limit of suction. The suction and delivery pipes were each 2 inches in diameter. The various speed limits reached under these varied conditions are shown in fig. 22 (p. 35), in the progressive diminution of discharge due to incomplete filling of the cylinder. The upstroke of the piston may be more rapid than the suction uprise of the water following it, in which case there will be separation of the piston from the following water. This separation may under certain conditions lead to a shock. The separation will begin, if at all, with the beginning of the upstroke; but the acceleration of the upstroke has a diminishing rate, while the speed of the following water may have an increasing rate. If the water overtake the piston about midway of its rise, the meeting will be without perceptible shock; if near the end of its stroke, the shock may be considerable. If, on the other hand, the piston has time to complete the upstroke and accomplish a part of its return, the shock may be severe.

It is these recurring shocks which produce what is called pounding. This action is shown in the accompanying diagrams, figs. 5 to 8, which exhibit the pull on the pump rod at various stages of its stroke. In fig. 5, *A*, the line x, from A to B, represents the length of the stroke, the direction AB the upstroke, the direction BA the downstroke. Vertical distances above the line x represent the pull in the pump rod. Thus, when the piston has reached the point C on the upstroke, the pull in the rod is represented by the line CD, and when it has reached the point E the stress is EF. On the return stroke the stress at E is EG, and at C it is CH. The figures here referred to are

from card diagrams, automatically drawn by a specially devised dynamometer, which was introduced into the pump rod of pumps in opertion, so that they record actual practice. The diagram shown in fig. 5, *A*, gives the results of the test of a 4-inch pump having a total lift of 38 feet, a 7-inch suction lift, 2-inch suction and delivery pipes, and a speed of thirty 14-inch strokes per minute, or an average piston speed of 70 feet per minute. The height of the line *ab* shows the pull necessary merely to support the column of water.

At the starting point, A, of the upstroke, the delivery valve closed, and the sudden pull on the rod which resulted is shown by the long vertical line. The depression immediately following is due to the spring of the pump rod and connections upon receiving the first large stress. The upward movement of the water column having become accelerated, a continually lessening pull is required to produce its discharge, as shown by the rapidly falling upper line. The suction valve closes at B, and the weight of piston and rod still produces a small tension in the rod. With excessive friction, or at high speed, this re-

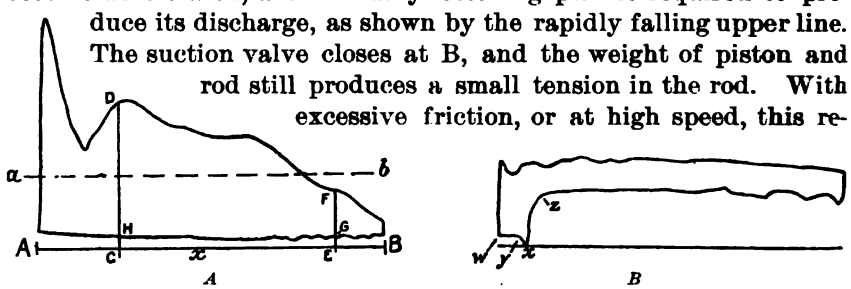


FIG. 5.—Dynamometer diagrams of pump-rod stresses. *A*, general; *B*, with suction lift of 30.8 feet, 30 strokes per minute.

turn-stroke line frequently falls in part below the zero line, showing compression in the pump rod.

In fig. 5, *B*, the pump was given a suction lift of 30.8 feet, with the same total lift and speed, however, as in fig. 5, *A*. The pull on the pump rod is seen to be very differently varied. On the upstroke this pull is much less, having only a small body of water to accelerate in addition to the weight of the atmosphere which it has to lift. The load remains nearly constant throughout the upstroke, the piston not being aided in its upward movement, toward the end, by the momentum of a rising column of water, as in fig. 5, *A*. On the return stroke the downward thrust is aided by the weight of the water in the delivery pipe as well as by the atmospheric pressure, and is resisted only by friction in the cylinder until the piston reaches the point *z*, where it encounters the slowly rising column of water. The blow of the piston against the rising water momentarily relieves the rod of tension, as shown by the drop in the vertical line in the diagram at *x*. This opposing pressure is at once dimished, however, by the opening of the piston valve. At *y* the suction valve closes and remains closed until opened at *w* on the upstroke.

If the piston speed had been slower the cylinder would have more nearly filled, as shown by the card (fig. 6, *A*) taken at 10 strokes

per minute, under which conditions the cylinder had become more than half filled before the shock of meeting. In fig. 6, *B*, the suction lift was 24.7 feet, and at a speed of 30 strokes per minute the cylinder had filled to the point *x*. In fig. 6, *C*, at a speed of 20 strokes, the rising water overtook the more slowly rising piston during the upstroke at the point *z*. In fig. 6, *D*, the speed was but 15 strokes per minute. In this case the following water overtook the piston near the middle of its upstroke, when the difference of speeds was not great, and the diagram in consequence shows at *a* but slightly reduced tension.

It is characteristic of this condition of high suction lift that with the same speed the upstroke of the pump starts more easily than when the cylinder is full, and that pounding may occur at any point in the last three-fourths of the stroke—the nearer its end the more

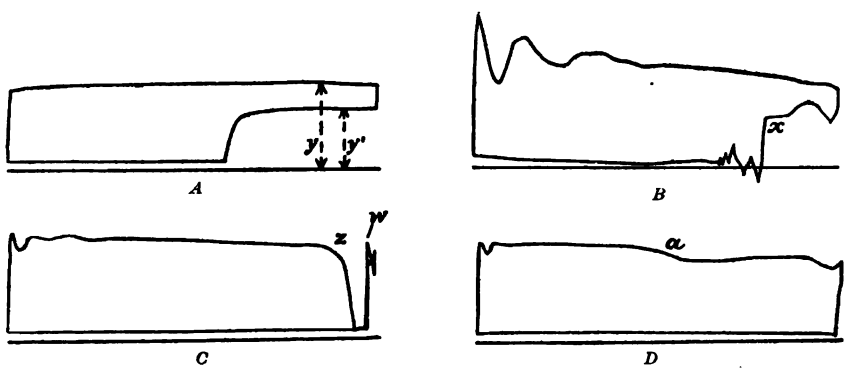


FIG. 6.—Dynamometer diagrams of pump-rod stresses. *A*, suction lift of 30.8 feet, 10 strokes per minute; *B*, suction lift of 24.07 feet, 30 strokes per minute; *C*, suction lift of 24.07 feet, 20 strokes per minute; *D*, suction lift of 24.07 feet, 15 strokes per minute.

severe. A sudden change or reversal of stress in the rod produces disastrous pounding and limits the speed of the pump. It should not be forgotten in this connection that it is weakening of suction head, as it might be called, that is the real cause of pounding, and that the difficulty may arise from undue frictional resistance to flow as well as from excessive suction lift.

It has been a common practice, in order to prevent an intake of sand where the suction pipe is itself the well and not merely a pipe suspended in an open well, to have the whole intake at the foot of the suction pipe through a screen. To the use of the screen there are objections of a serious nature, and the difficulty which is met by its use is best avoided entirely by resorting to the open well. However, if the screen is to be used at all, the total area of its perforations should be at least double the cross-section area of the suction pipe. Even then the screen openings will in time become clogged to such extent as greatly to increase the resistance. Not infrequently in a

pump with a screen intake failure to fill is wholly due to a clogged condition of the screen.

The introduction of elbows in the suction pipe is to be avoided wherever possible. The resistance to flow which they offer is considerable. Again, pipes of the smaller sizes are commonly cut with the rolling cutter, which raises a burr on the inside edge, thereby seriously reducing the entrance diameter. It is worth while to remove this burr. The following table shows the reduced cross-section area of a number of sizes of pipe cut with this tool:

Reduction of cross-section areas of pipes of various size cut with the rolling cutter.

	Diameter of pipe.						
	½-inch.	¾-inch.	1-inch.	1¼-inch.	1½-inch.	2-inch.	2½-inch.
Reduced area	*Per cent.* 87	*Per cent.* 77–83	*Per cent.* 83–90	*Per cent.* 80–88	*Per cent.* 85	*Per cent.* 90	*Per cent.* 95

Wherever, as sometimes happens, it becomes necessary to extend the suction pipe horizontally for any distance, such horizontal section should be given a larger diameter than that used in vertical sections. The larger volume of water which the head (B—S, fig. 4, p. 14) must move, together with the added friction of the increased length of pipe and of the necessary turns, reduces the velocity of the incoming water and fixes a lower limit to the possible piston speed.

UPSTROKE.

On the upstroke the pump simultaneously performs two distinct operations: It lifts directly the column of water L (fig. 4, p. 14) and the atmospheric column above it. By thus completely relieving of load the column of water below, it establishes the conditions under which that lower column is driven upward by the atmospheric pressure without. The resistances to upward movement above the delivery valve offered by the water are its hydraulic pressure, its inertia, and its friction. The hydraulic pressure depends on the height H, and is about 0.433 pound per square inch of piston area for each foot of height of water. If the discharge pipe is smaller than the cylinder, the velocity of the discharging water will be correspondingly greater. If the velocity be doubled, the frictional resistances, varying as the velocity squared, will be increased four times. Furthermore, water encounters resistance in making entrance into a pipe; wherefore it is desirable, when practicable, that the discharge pipe should have the same size as the cylinder. If the pump rod be carried through a stuffing box its friction therein will be considerable. There will be frictional loss also at the necessary turns in the delivery pipe, which loss may, however, be minimized by giving to these turns a long radius.

During the upstroke there is acceleration of speed at the outset and

retardation toward the close, the rate of acceleration diminishing toward the center of the stroke, and the rate of retardation increasing from that point toward the close of the stroke. The upward start of the water column is thus, in effect, somewhat abrupt, and in abruptly overcoming the inertia of this water column a pull is exerted upon the pump rod much in excess of that due to the weight of the water alone. This inertia resistance also varies as the velocity squared, and becomes a destructive resistance in fast-running pumps.

DOWNSTROKE.

At the finish of the upstroke the suction valve below closes, and the column of water above it remains at rest until the downstroke has been completed and another upstroke begun. During the descent of the piston through this stationary column of water the piston valve, or delivery valve, as it is called, is opened thereby. The resistances encountered on the downstroke are the frictional resistance of the piston packing and of the column of still water through which the piston has to be forced. It will be apparent that no useful work is accomplished on the downstroke; that all, on the other hand, is accomplished on the upstroke. In rising, the piston lifts B+L, and in turn is pressed upon from below by B—S, the difference between these forces being that force necessary to be applied to the rod and equal to H, fig. 4, p. 14. It is therefore evident that the force to be exerted is measured by the total height of the water lift and is independent of the relation of the suction lift to the direct lift.

VALVES.

There are two common forms of valves—the clack valve, which opens on a hinge, and the disk valve, which rises bodily on guides either at its circumference or along a central spindle. Valves of whatever variety should open and close readily, and should afford, when open, a water way as large and as direct as practicable. To open readily they must not be too heavy; on the other hand, for quick closing weight is an advantage. Also, to give free and large water passage they must have considerable amplitude of movement; yet, again, for quick closing such amplitude of movement is a disadvantage. Thus it appears that of necessity valve design is a matter of compromise among opposing conditions and requirements.

Some of the conditions which bear upon valve design are brought out in the following diagrams. Fig. 7 is the record made by an 8-inch pump having large clack valves, the smallest valve-opening area being 70 per cent of the cylinder cross-section area, and even this is an unusually large valve opening. These valves were in fact so large that, in the experiments, at only 25 strokes per minute they did not close until from 7 to 8 per cent of the stroke had been made. On

the return stroke the lower valve did not close until the piston had had time to travel from B to C (fig. 7), during which time, of course, water was escaping. This delay in closing and the consequent loss of water occurred at the very moderate piston speed of about 40 feet

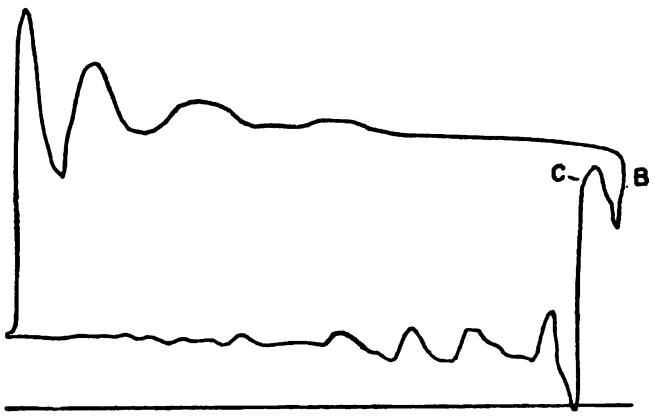


FIG. 7.—Dynamometer diagram of pump-rod stresses from an 8-inch pump having large clack valves. Piston speed, 40 feet per minute.

per minute. Its diagrammatic record exhibits the main defect in large clack valves.

Fig. 8 is the record made by a 6-inch pump using eight small clack valves for delivery valves, having a 14-inch stroke, and operated at a speed of 55 strokes per minute. The aggregate area of the valve openings was 15 per cent in excess of the cylinder cross-section area, yet at this high piston speed of more than 125 feet per minute the delay in the closing of these valves, as shown at A, was very small, being only about 2 per cent of the time interval of the whole stroke. The efficiency of this pump was very high. Thus there is seen to be decided advantage in the substitution, wherever practicable, of several small valve openings for a single large one. Valve lift is thereby minimized and quick closing secured, and without reduction in the aggregate area of valve opening.

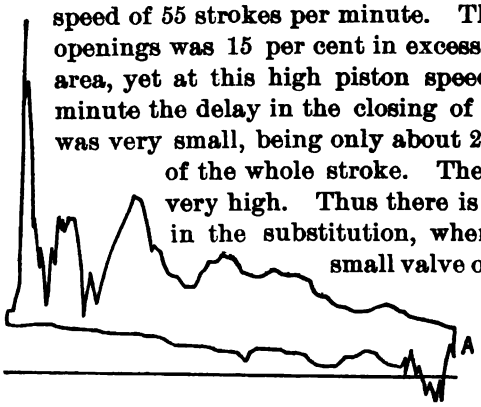


FIG. 8.—Dynamometer diagram of pump-rod stresses from a 6-inch pump having multiple small valves. Piston speed, 40 feet per minute.

That the discharge area around the edge of a clack valve shall equal that of the valve-seat opening, the valve must rise at its outer edge to a height equal to at least half the diameter of the valve opening. The diameter, in inches, of a clack-valve opening should not exceed 100 divided by the speed of the pump in strokes per minute. For example, a pump making 25 strokes per minute should have a clack-valve opening not exceeding in

diameter $\frac{100}{25}$, or 4 inches. Thus the clack valve is limited in use either to small pumps, to pumps of low speed, or to pumps of such design that they admit of the introduction of several small valves in substitution for a single large one.

With multiple valves the valve area should be equal to at least 50 per cent of the cylinder cross-section area. A modification[1] of the usual clack valve is presented in fig. 9, *A*, as an illustration of the manner in which some of the objections to this valve may be overcome. This modification consists in mounting upon the back of the large clack a second clack, covering a valve opening in the first. The tendency of the current of water to open widely the larger clack is in part overcome by the yielding of the smaller clack. It is claimed that higher speeds may thus be attained; also that the modification can readily be introduced into any large single clack already in use.

The advantages of the clack valve are its simplicity and its high efficiency at low speed. Being usually cut out of leather, as shown

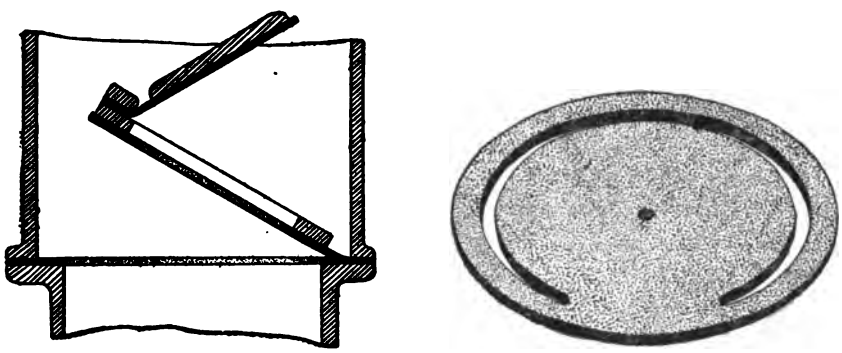


FIG. 9.—Clack valves: *A*, vertical section of double clack valve; *B*, leather suction valve.

in fig. 9, *B*, it is self-packing when closed and is self-hinged. It should be cut from a solid piece of leather, of uniform thickness and without soft spots. The width of the hinge should equal half the valve diameter, and the leather should be placed with the hair side to the seat. A metal disk slightly larger than the valve opening should be attached to the back of the valve, both to add to its stiffness and to give it weight.

Clack valves should have a small angle of lift in pumps running more than 15 strokes per minute. The resistance to flow through clack valves has been determined for the following angular openings:

Resistance to flow through clack valves.

	Degrees of lift.				
	15°	20°	25°	30°	40°
Resistance	*Per ct.* 64	*Per ct.* 53	*Per ct.* 32	*Per ct.* 21	*Per ct.* 10

[1] Barr.

If, for high speed, the valve lift be limited to about 30 degrees, or to an opening that, at its outer edge, is equal to half the valve diameter, the disadvantage of obstruction to flow will be about balanced by the advantage gained of quick closing.

A modification in form is the butterfly valve, in which the hinge is along a diameter line across the center of the leather disk, so that, instead of opening as one piece from a single point at the edge, it opens upward in two halves, back to back, like the wings of a butterfly, and is in effect a double valve. Fig. 27 (p. 48) shows such valves.

The disk valve is commonly but a circular metal plate, with one face adapted to fit a valve seat, and designed for a straight lift, within guides, either as shown in fig. 14 (p. 30), or in fig. 23 (p. 43). As a rule its vertical range is limited mechanically, but occasionally, as in fig. 23, the disk is merely weighted, and control of its range is left to the velocity of the incoming water, to which the weighting has been or can from time to time be adjusted. For low speeds, of about 20 strokes per minute, large disk valves work well, but for higher speeds the valves should be smaller. A valve of more that 5 inches diameter would be considered large. For quick-running pumps multiple valves from 3 to 4 inches in diameter are best.

In irrigation pumps the valve lift should not exceed 1½ inches. At that lift, and at a speed of 30 strokes per minute, about one-eleventh of a second is required for the drop-return of the valve disk, which involves a sacrifice of about 7 per cent of the stroke length. It is well to limit the valve diameter to four times the valve lift; and in the case of irrigation pumps, to 6 inches as a maximum.

The area between the edge of the disk and the cylinder walls should not be less than the valve-seat area. Where the cylinder is not enlarged into a valve chamber the valve area can not exceed about 40 per cent of the cylinder area, because of the necessary grids and lap of valves. It follows that the piston speed should fall well within 100 feet per minute; that is, in a pump with disk valves of this kind, having a 40 per cent valve opening and a 24-inch stroke, a speed of 25 strokes per minute should be considered high. This is a piston speed of 100 feet per minute.

In irrigation pumps the velocity of water through valves should not exceed 250 feet per minute. The speed of the piston at its maximum rate will be 1.57 times that at its average rate. In other words, when the average piston speed is 100 feet per minute there will be a maximum rate at about the middle of the stroke of 157 feet per minute; and this also will be the velocity of the water in the cylinder immediately ahead of the piston, but the water has to be forced through a contracted valve opening, and it must in consequence take on there a correspondingly increased velocity. If the valve opening be 40 per cent of that of the cylinder cross section, as above stated, the increase of velocity over that in the cylinder will then be from

157 feet per minute to 392 feet per minute. Hence an average piston speed of 100 feet per minute would be excessive. Experience with pumps of this class has shown that the best running speed is 60 feet per minute. It is found that beyond this speed the resistance offered by disk valves rapidly reduces the pump efficiency.

If the disk be weighted merely, and not limited in movement mechanically, it may be drawn up so far into the cylinder by the high velocity of the entering water that very late closing will result. The speed of the pump shown in fig. 27 (p. 48) is restricted thus to 50 strokes per minute. Fig. 10 gives the record of this pump when running at 55 strokes per minute. The suction valve was drawn up into the cylinder by the high speed of the water, and did not return to its seat until after half the downstroke had been completed. Seating at this late stage produced serious pounding.

For lifts exceeding 100 feet ball valves become desirable, because of

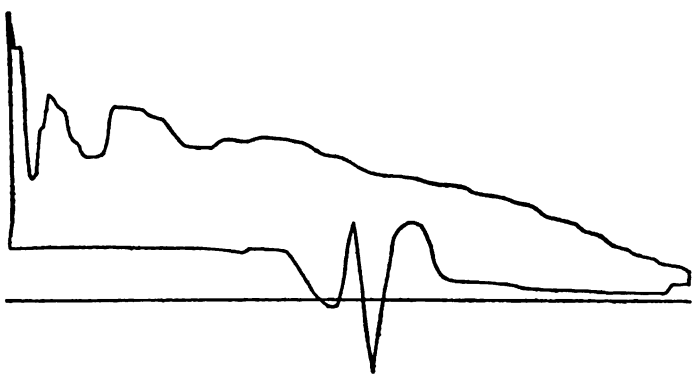


FIG. 10.—Dynamometer diagram of pump-rod stresses, showing late closing of suction valve.

the increased pressure. The ball should be solid and should fit into a metal seat. This form of valve is used in deep-well pumps, where, in order to secure greater strength of parts, it becomes necessary to reduce the valve area to a smaller percentage of the cylinder cross-section area.

PISTON AND ROD.

The piston of a pump is usually packed by means of cup leathers held between disks in the piston. Cup leathers can not well be homemade, as special appliances are necessary for their manufacture, and they had best be bought of dealers. The cup leather should not exceed three-fourths of an inch in width on the wearing surface. The water pressure holds the leather against the walls of the cylinder with considerable friction. This friction amounts, approximately, in pounds to $\frac{DWH}{3}$, D being the cylinder diameter in inches, W the width of the cup leather in inches, and H the lift of water in feet.

In a 6-inch cylinder, with a 20-foot lift, the piston friction will be about 30 pounds, or 12 per cent of the weight of the water lifted.

The piston friction, regarded thus as a percentage, is, approximately, $\frac{W}{D}$. To show the amount of this piston friction, reference is made to fig. 6, *A*. This diagram is from a pump having a 4-inch cylinder, a 14-inch stroke, and running at 10 strokes per minute. The suction lift was 30.8 feet, and the total lift was 38 feet. There was about 8 feet of water above the piston. The height y represents the pull on the rod due to the lifting of the 8 feet of water, the atmospheric pressure, and the weight of piston and rod, and to the overcoming of the friction of the cup leather.

The piston, once having left the water behind, is beyond the influence of the suction valve. The line y' represents the pull due to the load of nearly 8 feet of water, the atmospheric pressure, and the weight of piston and rod; but it does not represent in this case the friction of the piston, which, on the downstroke, tends rather to reduce the pull on the rod and to produce compression. The difference between y and y', therefore, represents twice the combined piston and water friction in the delivery pipe. At this speed the water friction in a straight pipe is very small, and the difference is almost entirely due to piston friction. In this case it amounts to 30 per cent of y. The piston friction was, therefore, 15 per cent of the whole work done, equivalent to about 18 per cent of the weight of water. The pump leather was three-fourths inch wide. By the above formula $\frac{W}{D}$ would give 18¾ per cent. The width of the packing leather is said to influence the friction very little in heavy hydraulic work, but it seems to be important with the lighter pressures of ordinary pumping.

Piston friction is a large factor in the problem, varying nearly directly as the lift and inversely as the cylinder diameter. The tendency is to render the efficiency of the larger cylinders the higher. Since a single leather has been found insufficient for the prevention of leakage in pumps working in deep wells, two, or sometimes even three, are used. Where these leathers can not readily be procured they can be made by soaking good harness leather until pliable and then bolting it into a wooden form. To make the form, a board about three-fourths inch thick, having in it a hole of the same diameter as the pump cylinder, is nailed to a stiff backboard, and a cylindrical block, three-eighths of an inch less in diameter, is bolted concentrically within the circular opening. The bolts should be long enough so that the wet and pliable leather, laid over the hole, can be drawn down by the bolts and block, forcing the leather into position. The wrinkled edge of the leather can then be trimmed off, and when the whole is dry, removed and brought to a thin and even edge with a sharp knife. The friction of the piston leather should not be so

great that on the downstroke the piston will not return by its weight alone.

Metal rods joined by screw couplings are commonly used in such pumps. By using a large rod a differential action is obtained in the delivery, rendering more uniform the work between the upstroke and the downstroke. A stiff rod is necessary where water is delivered on the downstroke. Wooden rods, because of their elasticity, frequently give less trouble at connections than metal rods, and where delivery pipes are large enough they are sometimes preferred.

PISTON SPEED.

Four factors tend to limit the piston speed: First, the excessive initial shock of lift on the upstroke; second, the tardy closing of valves; third, incomplete filling of the cylinder; fourth, the rapid lowering of general pump efficiency as the speed is increased.

To give to a body of water rapid motion necessitates a greater expenditure of energy than would be necessary simply to balance its static pressure. The acceleration of motion of the water is greatest at the beginning of the upstroke, and, as the rotative speed of the crank increases, the acceleration and the force necessary to produce it also increases. In practice the quantitative importance of this first stress is found to be largely a matter of pump design. If the rod is short and the pump connections and frame very rigid, the stresses will increase to a high limit earlier than when the machine has a certain lack of rigidity. The yielding of windmill towers to the various shocks of pump operation is in those structures a means of keeping down this stress. The extension and the elasticity of the pump rod also tend to soften the shock of starting the water column. The spring of parts is, therefore, in some degree, rather an advantage than otherwise, and the incorporation of a stiff spring into the pump rod would be advantageous.

In some of the pumps tested the pump rod had a length of about 40 feet and the machinery was placed upon an unusually rigid floor. Fig. 11 shows the maximum stress for a number of pumps tested from this floor. The horizontal distances represent average piston speed in feet per minute. With the pump piston at rest, the pump rod supported a certain constant load. With the pump piston in motion, this load no longer remained constant, but varied, being greater at the beginning of the stroke and at the end usually less; and this variation was found to increase as the speed increased. In fig. 11 distances above the base line exhibit this increase of stress. Vertical distances represent the maximum load while running, expressed in percentages of the quiet load. For example, in the test of one 4-inch pump it appeared that at a speed of 40 feet per minute the maximum load on the rod was 175 per cent of the quiet load, while at a speed of 80 feet per minute it was about 200 per cent. In

the test of another 4-inch pump, at these same speeds the corresponding percentages were 200 per cent and 400 per cent. At piston speeds of 70 feet per minute the initial stress may be equivalent to from two and one-half to five times the weight of the water. The percentages are greatest where loads are light. Where the parts are not of ample proportions, or where they are loosely assembled, the shocks due to this initial stress soon destroy the machine.

The stresses shown in fig. 11 may in large part be due to the late closing of valves. In fig. 12, delayed and sudden application of the load after the piston had acquired a high speed, at one-tenth of its upward stroke, produced a much more severe shock than would have

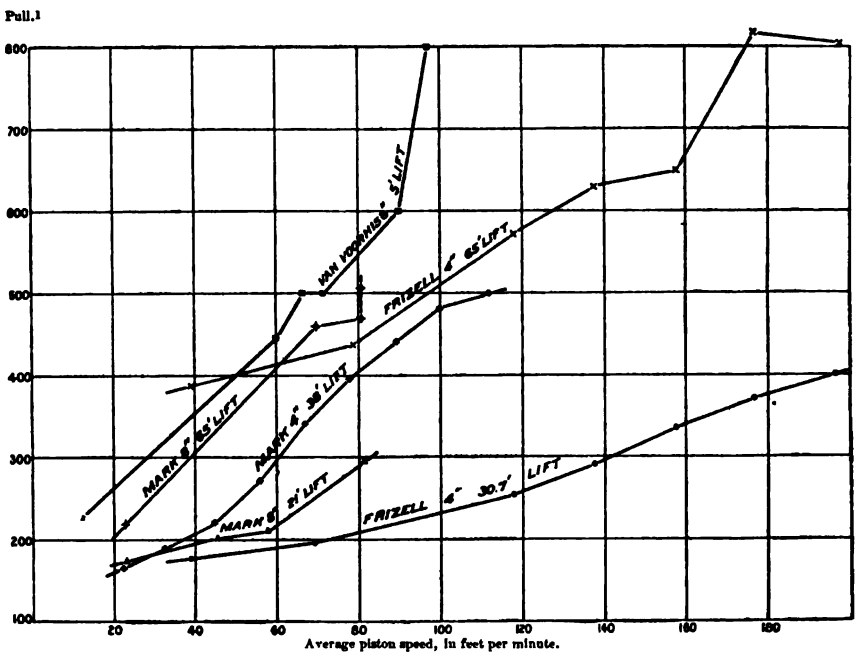


FIG. 11.—Diagram illustrating relation between piston speed and pull.

been felt if the valve had closed earlier. The effect of this slow closing of large valves is shown by the upper line in fig. 11. In the case of the lower valve it produces a blow on the under side of the piston, and frequently the shock of this blow is such as to jar a spray at each stroke from the upper surface of the water in the delivery pipe.

Incomplete filling of the cylinder limits piston speed, as shown in figs. 5, B (p. 16), to 6, D (p. 17). There is no advantage to be gained in running faster than the cylinder can fill. The upward tendency of the water into the cylinder depends rather upon other forces which we have called "head." We have seen that "suction" is the name

[1] Per cent of hydraulic pressure on the piston, representing maximum pull on the pump rod.

for an appearance rather than for an actual fact. The piston merely relieves the lower water column of load, and this column rises really under impulse from other agencies. It becomes the business, then, of the piston to keep the load that had held it down out of its way. Incomplete filling reduces the maximum stress nearly to that of a constant load, and indeed during the first part of the upstroke it results in more quiet running; but on the downstroke, on the other hand, with water and piston moving in opposite directions, it produces serious pounding.

Longer strokes admit of a much more rapid piston speed. This speed is limited by the number of times per minute the valves can open and close without serious shock and by the clear valve area. William Barr, in discussing steam pumps, says of the action of these valves: "The area of clear way through a set of valves in a water end should be not less than 40 per cent of the plunger area for speeds

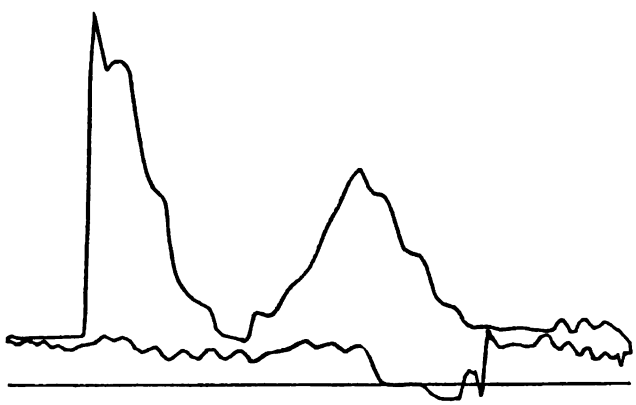


FIG. 12.—Dynamometer diagram of pump-rod stresses, showing excessive initial shock due to late closing of discharge valve.

of 100 feet per minute, 50 per cent for 125 feet, 60 per cent for 150 feet, 75 per cent for 175 feet, and 100 per cent for 200 feet per minute." With the usual windmill speeds, not exceeding 30 strokes per minute, a stroke of 2 feet would give a piston speed of 120 feet per minute, and should be possible with pumps having 50 per cent of clear valve area. Steam pumps, as stated by Barr, have a low efficiency as compared with some of the best forms of irrigation pumps; and while the above speed is possible, the valve area for high efficiency should be larger still. It is impossible accurately to set limits to pump speed, because it depends upon valve design and upon length of stroke, which in turn vary greatly in different forms of pumps.

The individual peculiarities of various makes are well brought out in fig. 11. The 4-inch Frizell pump, which gave the lowest maximum stress, and therefore made record of smooth running, had a valve area of but 27 per cent, while the 8-inch Van Voorhis pump, which

had 97 per cent of valve area and a short stroke, was noisy. In general it may be said of a reciprocating pump that a speed of 100 feet per minute is about all that should be expected. The following table shows the highest piston speed employed in the test of a number of irrigation cylinders. For a regular working speed it would be excessive

Speeds of piston in irrigation cylinders.

No. of fig. herein.	Diameter, in inches.	Stroke, in inches.	Speed, in feet per minute.
18	4	14.00	114
27	4	23.70	198
23	6	14.11	141
14	8	13.95	90
32	8	10.00	216

Weisbach says: "Usually the velocity of the piston is not over 78 feet per minute, the common valve ranging between 40 and 60 feet, though piston velocities of 196 feet sometimes occur." In some high-class pumping engines speeds of 480 feet have been obtained.

While it is possible to run at a high speed, it may not, for practical reasons, be desirable to do so. By referring to the diagrams showing the efficiencies of pumps of various design it is seen that all are more efficient at slow speeds. A fall in efficiency of about 15 per cent—up to 30 strokes per minute—is to be expected, even in a good pump. A large pump run slowly will, therefore, work with small power and to better advantage than a smaller pump at a higher speed. For the very best results in connection with a windmill a higher gearing than the usual 3 to 1 would be advisable, the limiting factor being the increased expense of the larger size of pump thus made necessary.

DISCHARGE.

The discharge of a pump per stroke is measured by the capacity of the cylinder within the stroke length, less, however, the amount by which the cylinder may have failed to fill on the upstroke, and less, as well, those losses on the downstroke which will result from backslip of water past the tardily closing valve and from leakage through the valve after closing. The discharge of various cylinders tested is given in diagrams accompanying the description of each. Reuleaux gives the discharge, in per cent of the geometrical displacement, as 92 per cent at a speed ranging from 27 to 40 strokes per minute, 95 per cent at 50 strokes, and 98 per cent at 60 strokes. At slow speed the leakage reduces the discharge by an amount ranging from 1 to 5 per cent. This loss diminishes, as a percentage, with increase of speed, but with high speed the loss from slow closing of valves rises and soon outweighs it. Weisbach states the loss to be from 5

to 15 per cent, which seems excessive for such cylinders as have been tested by the writer.

Where the velocity of water is high, owing either to a high piston speed or to a small pipe, the discharge per stroke may even exceed the cylinder capacity per stroke. The momentum of the rising water may be sufficient to hold the valves open for a brief interval after the completion of the upstroke, and thus for a moment to continue intake after the beginning of the downstroke. The paradoxical character of this effect is brought out by the discharge curves in figs. 19 (p. 32) and 22 (p. 35), and by the stress diagram, fig. 13. This stress diagram is a record from the work of the pump shown in fig. 18 (p. 32), and indicates that the tension on the rod in that pump, under the conditions imposed, was relieved by the momentum of the rising column of water before the end of the stroke had been reached, and that this momentum impulse continued effective until the lower valve had closed, at A (fig. 13), on the return stroke. This same effect may be observed when the suction pipe is carried to a considerable horizontal distance, increasing the weight of the moving water. Unless a suction chamber is put on in such cases, the suction pipe should increase in area directly as the length increases. Fig. 19 shows an example of the discharge being increased by a more rigid setting.

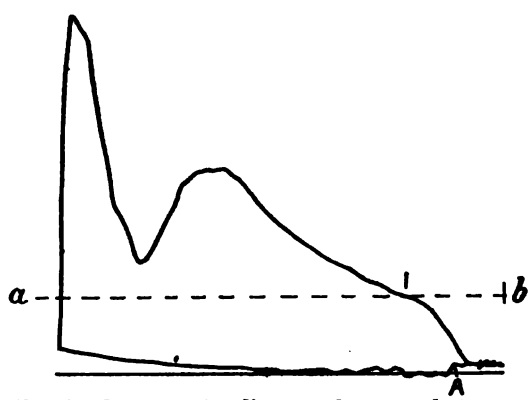


FIG. 13.—Dynamometer diagram of pump-rod stresses, showing excessive discharge.

EFFICIENCY OF PUMPS.

The efficiency of a pump is that percentage of the effort expended which is returned in useful work as water lifted. Efficiency will vary with the design, speed, and adaptation to the particular use. In small steam pumps the useful work done will account for only about 50 per cent of the power developed by the steam. Weisbach states the efficiency to be, "in well-designed pumps, working under favorable conditions, 80 per cent; in pumps of average perfection, 75 per cent; and in ordinary pumps, 70 per cent, and sometimes 65 per cent only." Mr. William O. Weber[1] gives the efficiency of reciprocating pumps as follows:

Efficiency of reciprocating pumps.

Lift (feet)	10	15	20	25	30	35	40	50	60	80	100	120	160	200	240	280
Efficiency	30	45	55	61	66	68	71	75	77	82	85	87	90	89	88	85

[1] Trans. Am. Soc. Mech. Eng., vol 7, p. 598.

To determine the usual range of efficiency for such pumps as are offered for irrigation purposes, and to determine what room there may be in them for improvement, the author has made something more than 1,000 measurements of various designs. The process by which were obtained the stress diagrams previously referred to affords a method for determining the amount of work, useful and otherwise, performed by the pump. By weighing the water discharged at various speeds and lifts a rating curve for each pump was obtained; and the useful work was determined by multiplying the weight of water discharged by the total lift. The diagrams show only the work actually performed by the pump rod, and therefore do not exhibit the ineffectual effort of the mechanism which transmitted power to the rod. The efficiencies are those of the pump cylinder and the pipes alone. They seem to show that some forms of the irrigation pumps tested here compare very favorably with those tested by others. Each pump has a particular sphere to which it is best adapted. No great increase of efficiency over the best now to be had is to be expected in any new form. Many of those now in the market could be much improved. The pumps represented in the drawings are typical, and by noting their performance, as shown in the following diagrams, the general range of efficiency of other pumps may often be closely approximated.

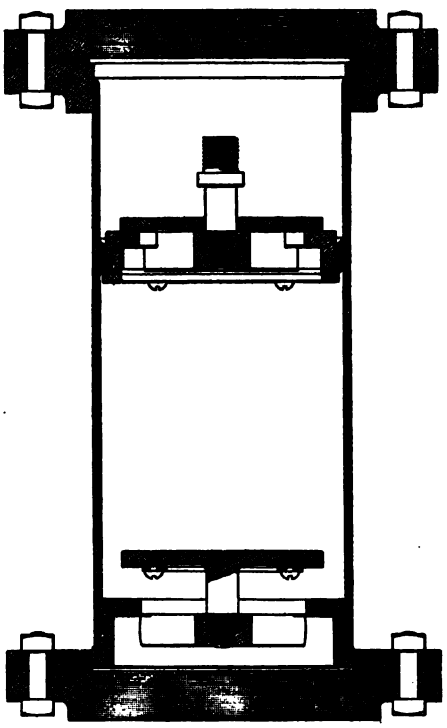


FIG. 14.—Vertical section of 8-inch brass cylinder with disk valves.

The efficiency is seen to rise with increase of lift and to fall with increase of speed. The maximum efficiency is reached at lifts lower than those of Weber's table. Certain pumps may be expected to have an efficiency above 80 per cent at the usual speeds and at moderate lifts. Efficiency with such will but slightly increase, if at all, at lifts of more than 50 feet.

MARK PUMP.

Fig. 14 shows an 8-inch brass cylinder having disk valves with limited movement. It is made by the Mark Manufacturing Company, of Chicago, Illinois, and is specially designed for irrigation work.

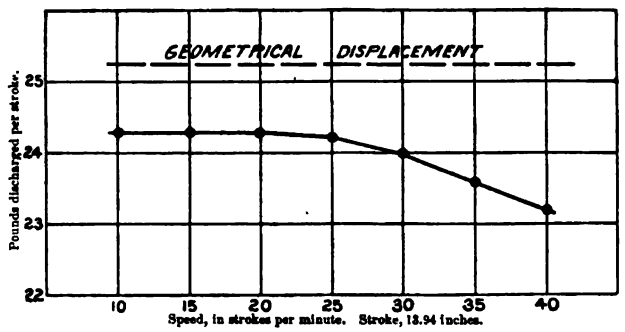


FIG. 15.—Discharge curve of 8-inch Mark pump.

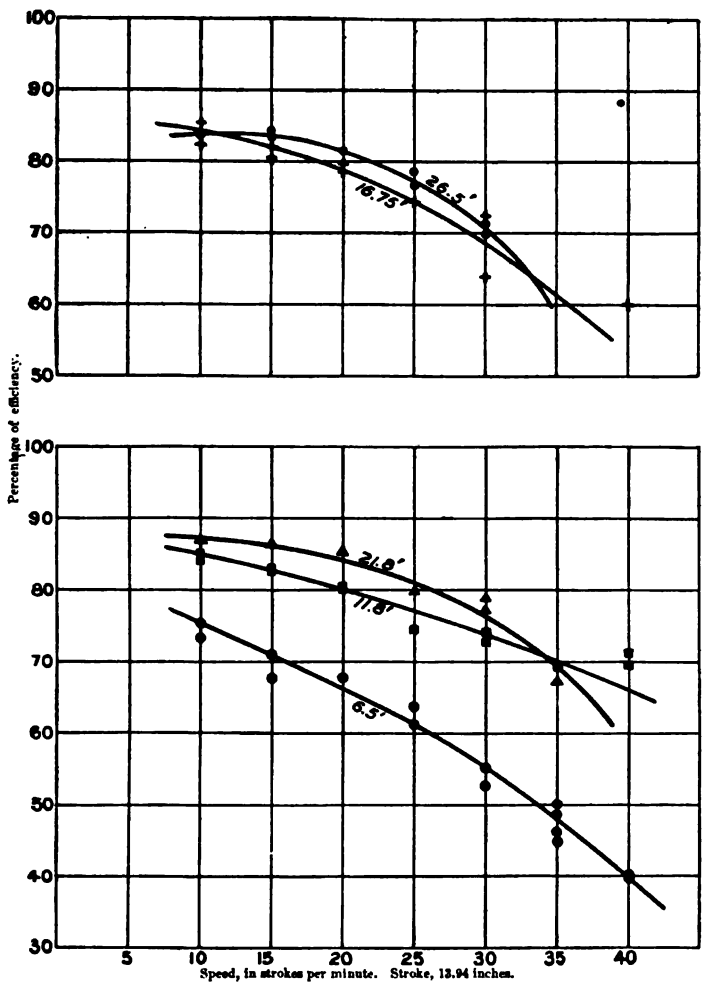


FIG. 16.—Varying-efficiency curve of 8-inch Mark pump, showing effect of varying height of lift and speed. (The line for 11.8 lift has been placed 10 per cent too high in the column 35–40. It should curve downward at the end and not cross the line 21.8.)

The lower valve is limited in movement by a cross attached to a pendent spindle on the valve disk. This valve is leather faced and has a clear opening of 36 per cent of the piston area. The upper valve area

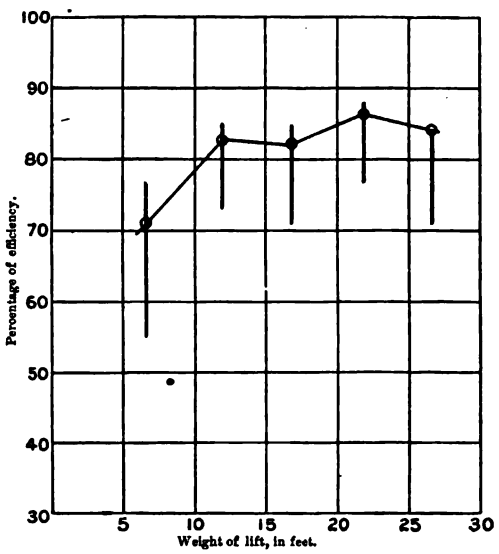


FIG. 17.—Variation of efficiency with varying height of lift of 8-inch Mark pump at speed of 15 strokes per minute.

is 34.7 per cent, the area between the edge of the disk and the cylinder walls is 53 per cent,

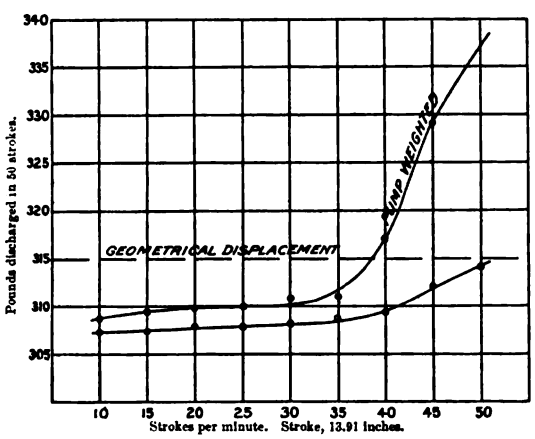


FIG. 19.—Discharge curve of 4-inch Mark pump.

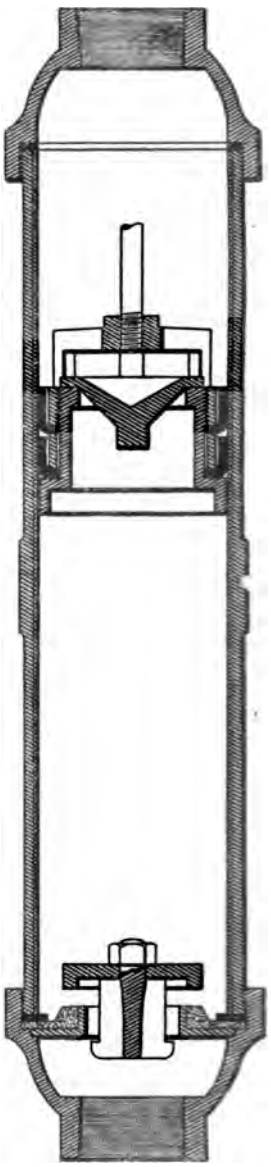


FIG. 18.—Vertical section of a brass-lined cylinder of small Mark pump.

and the area between the edge of the disk and the valve seat is slightly in excess of the valve area. The weight of the pump is 145½ pounds; of the piston and rod alone, 67½ pounds. The pump rod was a three-fourths-inch pipe, and

the delivery pipe was 6-inch. This pump is typical of the best design of those having large disk valves. It shows a very high efficiency at slow speeds, but a rapidly falling efficiency as the speed increases. Fig. 15 shows the discharge to be about 96 per cent of the geometrical displacement of the piston at a speed of 25 strokes per minute, but

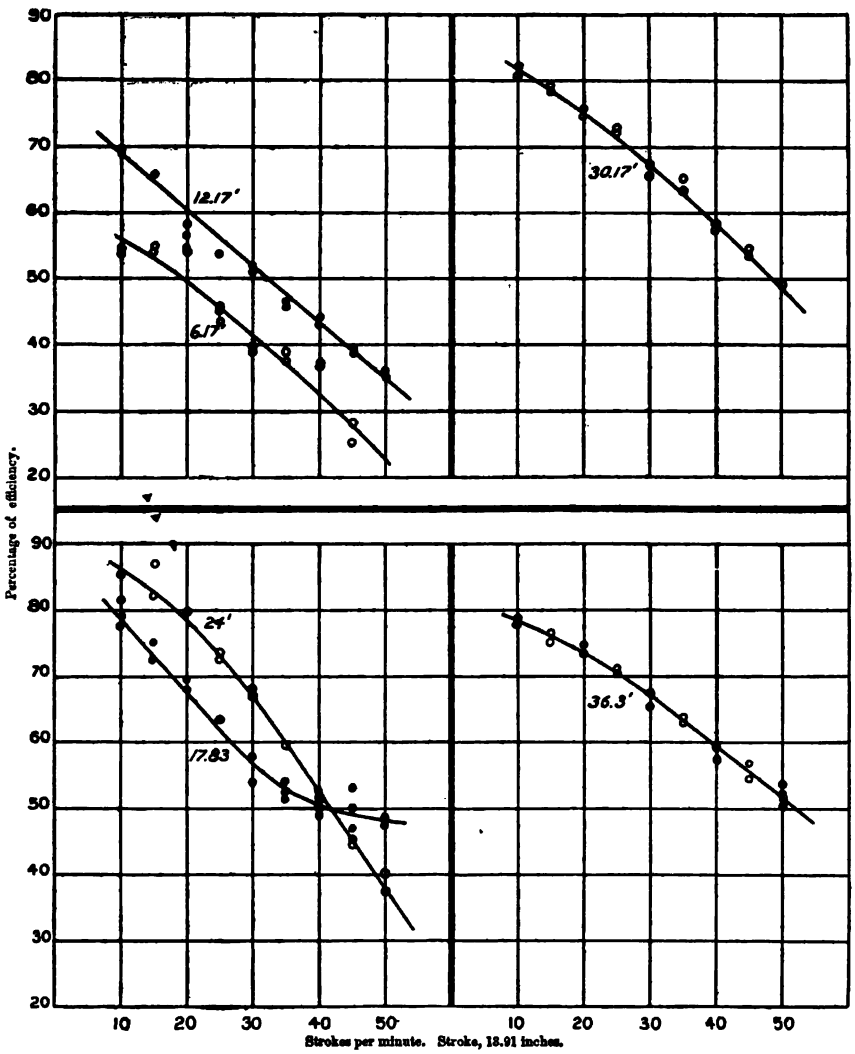


FIG. 20.—Varying-efficiency curves of 4-inch Mark pump, showing effect of varying height of lift and speed. (The lines for 17.83 and 24 should not cross. The diagram is erroneous in this respect. The correct figures for these curves are given on pages 37, 38.)

also shows that it has a falling rate beyond that speed. The efficiency is high for strokes fewer than 20 per minute, and at lifts exceeding 10 feet. Fig. 16 shows the efficiency curves at five lifts, from 6½ to 26½ feet.

In fig. 17 the heavy vertical lines show the range of efficiency at varying speeds at each lift, and the irregular line joining those points represents the efficiencies at a speed of 15 strokes per minute. It would seem from this diagram that a considerable increase of efficiency at a higher lift is not to be expected.

Fig. 18 gives a section of a brass-lined cylinder of the same make, which is typical of the better-made small pumps that provide for a suction and discharge pipe of less diameter than the cylinder. It has a 14-inch stroke, with a metal disk-valve carried in the piston. The upper valve area is 30 per cent of the cylinder area. The lower metal valve seats on a rubber ring. The lower valve area is 18 per cent. The suction and delivery pipes are 2-inch.

Fig. 19 shows two discharge curves of this pump. When rigidly

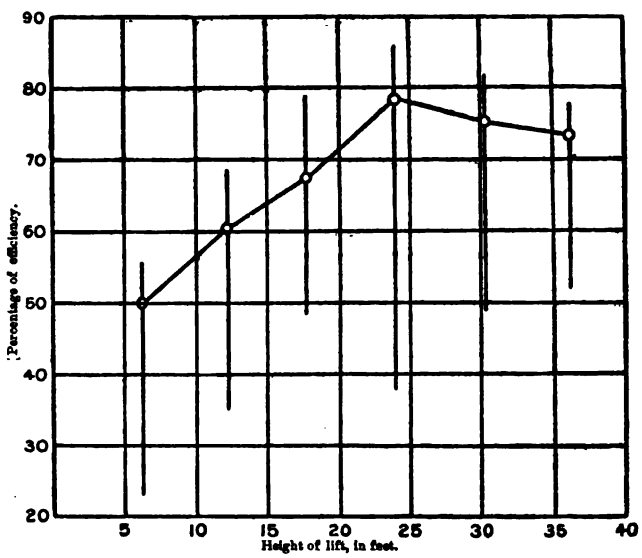


FIG. 21.—Variation of efficiency with varying height of lift of 4-inch Mark pump at speed of 20 strokes per minute.

held, so that the rapidly moving water could not jar the pump and pipe, the discharge was greater than when simply suspended in the well, as usual. The discharge is greater than the geometrical displacement of the piston at speeds above 38 strokes per minute, owing to the high velocity of the water in a small pipe. The efficiencies at six different lifts are given in the tables, and in the diagram, fig. 20. The rapidly lowering efficiency shows the effect of small connections and of small valve area.

From fig. 21 the maximum efficiency seems to be reached at about a 25-foot lift. This pump was used in an interesting test which brought out the effect of varying the suction lift. The total lift—suction and direct together—was 38 feet. The cylinder was placed at different heights in the pipe, giving different heights of suction, ranging from

nothing to 30¼ feet. Fig. 22 shows the effect on the discharge of the varying suction lift. In all cases, as the speed increases, the tendency

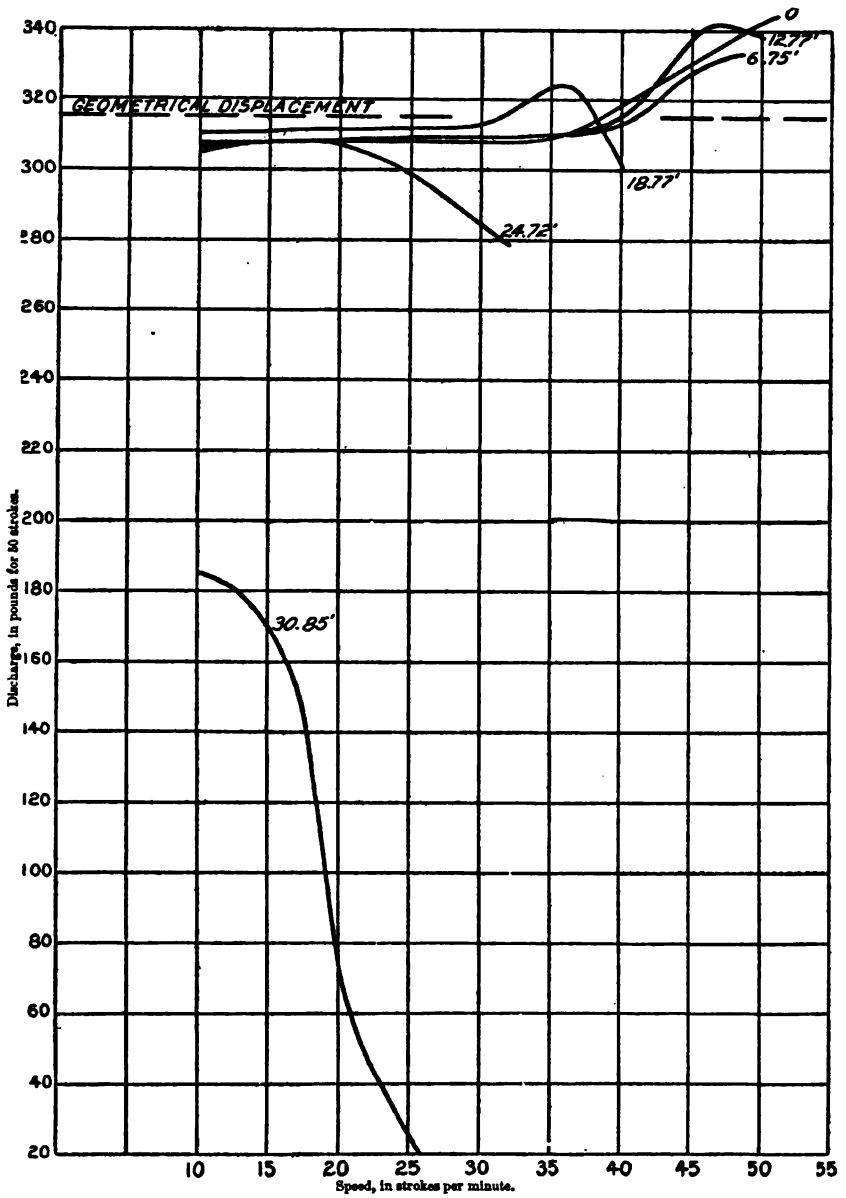


FIG. 22—Discharge curve for 4-inch Mark pump at a total lift of 38 feet and at various suction lifts.

is to increase the discharge; but when the lift gets to be so great that the atmospheric pressure is unequal to the filling of the cylinder the discharge curve rapidly falls. This maximum rise of the curve is seen

to occur earlier with each successive increase in the suction lift. Figs. 5, *B* to 6, *D* (pp. 16, 17) give diagrams of stresses in the pump-rod, and may be compared with fig. 5, *A*, which is typical of normal conditions. The tables present the results of suction tests.

Discharge of 8-inch Mark pump stroke, 13.94 inches.

Speed.[1]	Discharge for 15 strokes; lift, 6.5 feet.	Discharge for 15 strokes; lift, 11.8 feet.	Discharge for 15 strokes; lift, 26.5 feet.	Plotted average discharge per stroke.
10	367¼	371	356	24.30
10	369¼	369	355¼	
15	366¼	368¼	358¼	24.30
15	368	362¼	357¼	
20	368	369¼	358	24.30
20	365¼	367	358¼	
25	365	369¼	355¼	24.266
25	365	370¼	358¼	
30	358	367	351¼	24
30	358	361¼	351¼	
35	346¼	358		23.60
35	348	356¼		
40	337¼	359		23.20
40	352	357		

[1] Strokes per minute.

Figures from efficiency tests of 8-inch Mark pump; stroke, 13.94 inches.

LIFT, 6.5 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on the rod.	Foot-pounds of work given to the rod.	Mechanical efficiency.	Maximum tension on the rod.	Minimum tension on the rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*	*Pounds.*
10	24.300	157.95	184.72	214.28	73.7	312	72
10	24.300	157.95	179.64	208.38	75.7		
15	24.300	157.95	200	232.36	67.9		
15	24.300	157.95	191.52	222.16	71.1		
20	24.300	157.95	200	232.36	67.9		
20	24.300	157.95	200.16	232.50	67.8		
25	24.266	157.73	213.36	247.50	63.7		
25	24.266	157.73	220.32	255.57	61.3		
30	24	156	244.04	283.08	55.1		
30	24	156	252.52	292.92	53.2	648	— 72
35	23.600	153.40	284.72	330.28	46.4		
35	23.600	153.40	271.16	314.55	48.7	664	— 80
35	23.600	153.40	289.80	336.17	45.6		
35	23.600	153.40	259.32	300.81	50.9	738	—108
35	23.600	153.40	266.94	309.65	49.5		
40	23.200	150.80	325.38	377.44	39.7		
40	23.200	150.80	320.04	371.25	40.5		

LIFT, 11.8 FEET.

10	24.30	286.74	293.60	340.58	84.2	480	70
10	24.30	286.74	290.60	337.10	85		
15	24.30	286.74	297	344.52	83.2		
15	24.30	286.74	298.05	345.74	82.9		
20	24.30	286.74	308.50	357.86	80.2		
20	24.30	286.74	305.55	354.44	80.8		
25	24.266	286.34	311.95	385.06	74.3		
25	24.266	286.34	311.95	385.06	74.3		
30	24	283.20	328.95	381.58	74.2		
30	24	283.20	335.45	389.12	72.8	650	— 25
35	23.60	278.48	346.80	402.29	69.2	700	— 50
35	23.60	278.48	346.80	402.29	69.2		
40	23.20	273.76	384.60	446.14	61.3		
40	23.20	273.76	395.30	458.55	59.4	1,140	—100

Figures from efficiency tests of 8-inch Mark pump; stroke, 13.94 inches—Cont'd.

LIFT, 16.75 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on the rod.	Foot-pounds of work given to the rod.	Mechanical efficiency.	Maximum tension on the rod.	Minimum tension on the rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*	*Pounds.*
10	24.30	407.03	426.22	494.68	82.3	585	60
10	24.30	407.03	419.85	487.45	85.1		
15	24.30	407.03	435.90	506.08	80.4		
15	24.30	407.03	429.45	498.16	81.7		
20	24.30	407.03	445.50	516.78	78.7		
20	24.30	407.03	441.97	512.69	79.5		
25	24.266	406.47	458.32	531.66	76.4		
25	24.266	406.47	467.92	542.79	74.8		
30	24.00	402.00	477.52	552.93	72.5	900	0
30	24.00	402.00	529.72	619.48	63.9		
35	23.60	395.30	555.30	644.15	61.3	1,170	—150
40	23.20	388.60	558.45	647.80	59.9	1,245	—150
40	23.20	388.60	564.82	655.20	59.3		

LIFT, 21.8 FEET.

10	24.300	529.74	536.18	607.67	87.1	825	75
10	24.300	529.74	536.18	607.67	87.1		
15	24.300	529.74	539.47	611.40	86.6		
15	24.300	529.74	539.47	611.40	86.6		
20	24.300	529.74	549.30	622.54	85.1		
20	24.300	529.74	546.00	618.80	85.6	960	75
25	24.266	529.01	582.24	659.87	80.2	997.5	—37.5
25	24.266	529.01	583.65	661.47	79.9		
30	24.000	523.20	595.35	674.73	77.5		
30	24.000	523.20	595.35	674.73	77.5		
30	24.000	523.20	585.52	663.59	78.8		
35	23.600	514.48	684.15	775.37	69.8	1,387.5	—165
35	23.600	514.48	707.17	811.46	67.5		

LIFT, 26.5 FEET.

10	24.300	643.95	684.15	775.37	83.5	997.5	45.0
10	24.300	643.95	680.85	771.83	83.6		
15	24.300	643.95	677.62	767.97	83.8		
15	24.300	643.95	674.32	764.23	84.2		
20	24.300	643.95	694.05	786.59	81.8		
20	24.300	643.95	697.35	790.33	81.4		
25	24.266	643.06	720.37	816.42	78.7	1,275	—37.5
25	24.266	643.06	740.77	839.44	76.6		
30	24.000	630.00	786.15	890.97	71.3		
30	24.000	630.00	801.67	908.56	69.9		

Discharge of 4-inch Mark pump at various speeds and lifts.

Speed.	Discharge, in pounds, for 50 strokes for lift:				Average discharge, in pounds, per stroke by discharge curve.
	6.17 feet.	12.17 feet.	24.2 feet.	30.17 feet.	
10	309.5	311	304	307	6.146
10	306.5	309.5	303.5	307.5	
15	306	312	305	309	6.148
15	306	309	305.5	308	
20	306	310.5	308	307	6.152
20	305.5	310.5	308.5	308	
25	303	310.5	309	307	6.156
25	305.5	308	308.5	309.5	
30	308	308	312.5	309	6.16
30	306	307	309.5	307	
35	309	308.5	310	307	6.17
35	309	308.5	311	308.5	
40	306	309.5	311.5	311	6.192
40	306.5	308.5	309	313	
45	300	312	321		6.24
45	301	310.5	328.5		
50		314.5			6.28
50		313.5			

Discharge of 4-inch Mark pump at various lifts and speeds; pump cylinder heavily weighted.

Speed.	Discharge, in pounds, for 50 strokes for lift:		Average discharge, in pounds, per stroke by discharge curve.	Speed.	Discharge, in pounds, for 50 strokes for lift:		Average discharge, in pounds, per stroke by discharge curve.
	30.17 feet.	36.3 feet.			30.17 feet.	36.3 feet.	
10	308.5	305.5	6.16	30	311.5	310	.....
10	308.5	303.5	.....	35	311	310.5	6.23
15	311.5	308.5	6.192	35	311.5	310.5	.....
15	312	307	.....	40	314.5	321	6.34
20	311.5	308.5	6.196	40	317	316	.....
20	312	307.5	.....	45	332	328	6.584
25	312	308	6.198	45	328	329	.....
25	310.5	309	.....	50	339.5	331.5	6.744
30	312	309.5	6.204	50	341	337	.....

Figures from efficiency tests of 4-inch Mark pump; stroke, 13.91 inches.

LIFT, 6.17 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum pull on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*
10	6.146	37.92	60.58	70.21	54	81
10	6.146	37.92	59.93	69.46	54.6	.....
15	6.148	37.94	60.58	70.21	54	.....
15	6.148	37.94	59.62	69.1	54.9	.....
20	6.152	37.96	59.68	69.17	54.8	.....
20	6.152	37.96	60.58	70.21	54	.....
20	6.152	37.96	59.23	68.65	55.3	107
25	6.156	37.98	72.44	83.95	45.2	.....
25	6.156	37.98	71.47	82.84	45.8	132
25	6.156	37.98	75	78.12	43.6	.....
30	6.16	38.01	82.37	95.47	39.8	.....
30	6.16	38.01	83.97	97.33	39	158
35	6.17	38.07	86.86	100.7	37.8	159
35	6.17	38.07	86.86	100.7	37.8	.....
40	6.192	38.21	88.5	102.5	37.2	.....
40	6.192	38.21	89.42	103.6	36.8	.....
45	6.24	38.5	117.4	136.1	28.2	.....
45	6.24	38.5	131.8	152.8	25.2	294
48	6.27	38.69	173.3	200.9	19.2	.....

LIFT, 12.17 FEET.

10	6.146	74.8	93	107.8	69.3	117
10	6.146	74.8	92.6	107.3	69.6	.....
15	6.148	74.82	97.7	113.4	65.9	159
15	6.148	74.82	97.7	113.4	65.9	.....
20	6.152	74.87	110.7	128.3	58.3	147
20	6.152	74.87	113.6	131.7	56.8	.....
25	6.156	74.92	120.8	140	53.5	.....
25	6.156	74.92	120.2	139.3	53.7	.....
30	6.16	74.97	124.3	144.1	52	.....
30	6.16	74.97	126.6	146.7	51	223
35	6.17	75.09	139.1	161.2	46.5	255
35	6.17	75.09	140.1	162.4	46.2	.....
40	6.192	75.3	146.5	169.8	44.4	.....
40	6.192	75.3	150	173.8	43.3	300
45	6.24	75.94	166.7	193.2	39.3	.....
45	6.24	75.94	165.4	191.7	39.6	366
50	6.28	76.4	187	216.8	35.2	.....
50	6.28	76.4	182.7	211.7	36.1	372

Figures from efficiency tests of 4-inch Mark pump; stroke, 13.91 inches—Continued.

LIFT, 17.88 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum pull on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*
10	6.146	109.6	119.5	139	79.1	210
10	6.146	109.6	121.5	140.9	77.8	.....
15	6.148	109.6	126.1	146.1	75	.....
15	6.148	109.6	130.5	151.3	72.4	.....
20	6.152	109.7	139	161.1	68	.....
20	6.152	109.7	135.7	157.3	69.7	225
25	6.156	109.8	137	158.8	69.1	264
25	6.156	109.8	148.7	172.4	63.7	270
30	6.16	109.8	162.9	188.8	58.1	375
30	6.16	109.8	175.1	202.9	54.1	411
35	6.17	110	183.5	212.6	51.7	432
35	6.17	110	175.6	208.3	52.8	420
40	6.192	110.4	184.3	213.6	51.7	.....
40	6.192	110.4	189.4	219.6	50.3	489
45	6.24	111.3	211.8	245.5	45.3	555
45	6.24	111.3	213.7	248.7	44.9	.....
50	6.28	112	239.5	277.6	40.3	.....
50	6.28	112	257.5	298.4	37.5	684

LIFT, 24.2 FEET.

10	6.146	148.7	150	173.8	85.5	228
10	6.146	148.7	157.2	182.2	81.6	234
10	6.146	148.7	147.4	170.8	87	225
15	6.148	148.8	156.5	181.4	82	255
15	6.148	148.8	156.5	181.4	82	258
20	6.152	148.9	161.1	186.7	79.7	285
20	6.152	148.9	161.1	186.7	79.7	285
25	6.156	149	177.3	205.5	72.5	348
25	6.156	149	174.7	202.5	73.6	345
30	6.16	149.1	188.8	218.8	68.1	447
30	6.16	149.1	191.4	221.8	67.2	471
35	6.17	149.3	215.3	249.5	59.8	558
35	6.17	149.3	200.4	232.3	64.2	501
40	6.192	149.8	262.7	304.4	49.2	720
40	6.192	149.8	244.6	283.5	52.8	669
45	6.24	151	243.6	282.3	53.5	665
45	6.24	151	242.4	281	53.7	640
45	6.24	151	275.8	319.6	47.2	.....
45	6.24	151	257.5	298.4	50.6	760
50	6.28	152	267.2	309.5	49	775
50	6.28	152	274.7	318.4	47.7	775

LIFT, 30.17 FEET.

10	6.146	185.4	195.6	226.7	81.7	300
10	6.146	185.4	191.3	221.7	83.6	305
15	6.148	185.5	198.9	230.5	80.4	360
15	6.148	185.5	200	231	80	345
20	6.152	185.6	206.7	239.6	77.4	380
20	6.152	185.6	206.7	239.6	77.4	390
25	6.156	185.7	208.9	242	76.7	410
25	6.156	185.7	211	244.6	75.9	410
30	6.16	185.8	235.9	273.4	67.9	535
30	6.16	185.8	234.8	272.2	68.2	535
35	6.17	186.1	255.4	296	62.8	650
35	6.17	186.1	257.6	298.5	62.3	675
40	6.192	186.8	260.8	302.3	61.8	675
40	6.192	186.8	265.1	307.3	60.8	700
45	6.24	188.2	283.4	328.5	57.3	830
45	6.24	188.2	288.8	334.7	56.2	820

Figures from efficiency tests of 4-inch Mark pump; stroke, 13.91 inches—Continued.

LIFT, 30.17 FEET.

[Pump heavily weighted.]

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum pull on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*
10	6.16	185.8	195.9	227	81.8	315
10	6.16	185.8	194.8	225.8	82.3	305
15	6.192	186.8	204.3	236.8	78.8	350
15	6.192	186.8	203.2	235.6	79.3	350
20	6.196	186.9	216.3	250.7	74.5	410
20	6.196	186.9	213	246.9	75.7	415
25	6.198	187	222.8	258.2	72.4	490
25	6.198	187	220.6	255.7	72.7	480
30	6.204	187.2	240.3	278.5	67.2	575
30	6.204	187.2	245.7	284.7	65.7	595
35	6.23	187.9	248.9	288.5	65.1	630
35	6.23	187.9	254.3	294.7	63.7	615
40	6.34	191.2	281.2	326	58.6	730
40	6.34	191.2	285.5	330.9	57.8	755
45	6.58	197.6	318.7	369.4	53.7	880
45	6.58	197.6	314.1	364	54.5	845
50	6.744	203.5	356.8	413.6	49.2	1,000

LIFT, 36.3 FEET.

[Pump heavily weighted.]

10	6.16	223.6	244.6	283.5	78.9	355
10	6.16	223.6	245.6	284.7	78.5	350
15	6.192	224.8	253.3	293.5	76.5	415
15	6.192	224.8	256.5	297.3	75.6	440
20	6.196	224.9	263	304.8	73.8	465
20	6.196	224.9	259.7	301	74.7	465
25	6.198	225	272.7	316.1	71.1	560
25	6.198	225	273.8	317.3	70.9	570
30	6.204	225.2	287.7	333.5	67.5	680
30	6.204	225.2	296.3	343.4	65.5	700
35	6.23	226.1	307.9	356.9	63.3	760
35	6.23	226.1	306.9	355.7	63.6	760
40	6.34	230.2	335.8	389.3	59.1	875
40	6.34	230.2	343.3	398	57.8	925
45	6.584	239	360.5	417.9	57.2	925
45	6.584	239	367	425.3	54.9	985
50	6.744	244.8	418 5	485	50.4	1,035
50	6.744	244.8	391.6	453.9	53.9	1,000
50	6.744	244.8	403.4	467.6	52.3	1,050
50	6.744	244.8	403.4	467.6	52.3	1,065
50	6.744	244.8	409.9	475.1	51.5	1,000

Plotted averages of discharge per stroke, suction test of 4-inch Mark pump.

Speed.	Discharge, in pounds, per stroke.					
	Total lift, 38 feet; suction lift, 30.85 feet.	Total lift, 37.96 feet; suction lift, 24.77 feet.	Total lift, 38 feet; suction lift, 18.77 feet.	Total lift, 37.96 feet; suction lift, 12.77 feet.	Total lift, 37.92 feet; suction lift, 6.73 feet.	Total lift, 37.92 feet; suction lift, 0.6 foot.
10	185.5	6.11	6.21	6.16	6.13	6.14
15	172.5	6.154	6.226	6.168	6.16	6.15
20	79.5	6.15	6.23	6.176	6.168	6.156
25	25.5	5.996	6.234	6.184	6.174	6.16
30	7.5	5.730	6.256	6.192	6.178	6.164
35	.....	.....	6.46	6.2	6.184	6.184
40	.....	.....	6.024	6.266	6.250	6.34
45	.....	.....	.....	6.754	6.56	6.556
50	.....	.....	.....	6.78	6.68	6.706

Discharges of 4-inch Mark pump at various suction lifts and speeds.

Speed.	Discharge, in pounds, for 50 strokes.					
	Total lift, 38 feet; suction lift, 30.85 feet.	Total lift, 37.96 feet; suction lift, 24.77 feet.	Total lift, 38 feet; suction lift, 18.77 feet.	Total lift, 37.96 feet; suction lift, 12.77 feet.	Total lift, 37.92 feet, suction lift, 6.73 feet.	Total lift, 38.08 feet; suction lift, 0.6 foot.
10	185.5	306	311.5	308.5	306.5	306.5
10		305	309.5	307.5	306.5	307.5
15	172.5	310.5	311	306.5	307.5	307
15		305	312	309.5	306.5	308
20	79.5	308.5	312.5	307.5	309	308.5
20		306.5	310	310	309.5	307
25	25.5	299.5	313	310.5	308.5	307
25		300	311	309	308.5	309.5
30	7.5	290	312.5	308	309	308
30		283.5	313	309	309	307
35			323	311	309.5	311.5
35			323	309	309	307
40			301.5	312.5	312.5	318.5
40			301	314		318.5
45				337.5	328	
45				338		
50				340	334	331.5
50				338		339

Figures from suction test of 4-inch Mark pump.

TOTAL LIFT, 38.08 FEET; SUCTION LIFT, 0.6 FOOT.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum pull on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*
10	6.14	233.8	253.3	298.6	79.6	350
10	6.14	233.8	256.6	297.4	78.6	370
15	6.15	234.2	257.7	298.6	78.4	390
15	6.15	234.2	257.7	298.6	78.4	400
20	6.156	235.4	263.1	304.9	76.8	460
20	6.156	235.4	267.5	310	75.6	470
20	6.156	235.4	264.2	306.2	76.5	470
25	6.16	235.5	275.1	318.8	73.5	530
25	6.16	235.5	276.1	320	73.3	530
30	6.164	235.7	297.8	345.2	68	710
30	6.164	235.7	316.3	366.6	64	760
35	6.184	235.6	322.8	374.2	62.9	780
35	6.184	235.6	340.2	394.3	59.7	860
40	6.34	241.4	359.3	416.4	57.9	910
40	6.34	241.4	368	426.5	56.6	920
45	6.556	249.6	394	456.6	54.6	990
45	6.556	249.6	390.7	452.8	55.1	1,000
50	6.706	255.4	415.6	481.7	53	1,060
50	6.706	255.4	418.8	485.4	52.6	1,030

TOTAL LIFT, 37.92 FEET; SUCTION LIFT, 6.73 FEET.

10	6.13	232.4	245.1	284	81.8	360
10	6.13	232.4	243.5	282.2	82.3	375
15	6.16	233.6	256.5	297.3	78.5	435
15	6.16	233.6	255.5	296.1	78.9	435
20	6.168	233.9	266.4	308.7	75.7	490
20	6.168	233.9	270.7	313.8	74.5	505
25	6.174	234.1	287.1	332.8	70.3	585
25	6.174	234.1	292.6	339.1	69	630
30	6.178	234.2	302.2	350.2	66.9	660
30	6.178	234.2	315.2	365.3	64.1	720
35	6.184	234.5	332.2	385.1	60.9	785
35	6.184	234.5	332.2	385.1	60.9	800
40	6.25	237	359.9	416.9	56.8	870
40	6.25	237	381.5	442.1	53.6	950
45	6.56	248.8	422.4	489.6	50.8	1,005
45	6.56	248.8	404.1	468.3	53.1	960
50	6.68	253.3	468.8	543.3	46.6	1,160
50	6.68	253.3	472	547.1	46.3	1,050

Figures from suction test of 4-inch Mark pump—Continued.

TOTAL LIFT, 37.96 FEET; SUCTION LIFT, 12.77 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum pull on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*
10	6.16	223.8	254.4	294.8	79.3	370
10	6.16	233.8	252.2	292.3	80	380
15	6.168	234	256	296.7	78.9	410
15	6.168	234	260.4	301.8	77.5	410
20	6.176	213.8	263.1	304.9	76.8	460
20	6.176	213.8	264.2	306.2	76.5	440
25	6.184	234.7	277.3	321.4	73	560
25	6.184	234.7	282.8	327.7	71.6	560
30	6.192	235	301.3	349.2	67.3	650
30	6.192	235	299.1	346.7	67.8	640
35	6.2	235.4	319.6	370.4	63.5	715
35	6.2	235.4	318.5	369.1	63.7	705
40	6.266	237.9	394.6	457.3	52	915
45	6.754	256 4	414.1	480	53.4	885
45	6.754	256.4	407.6	472.4	54.2	885
45	6.754	256.4	439.1	508.9	50.3	----------
45	6.754	256.4	430.4	498.9	51.4	----------
50	6.78	257.4	431.8	500.5	51.4	----------
50	6.78	257.4	443.7	514.3	50	1,000

TOTAL LIFT, 38 FEET; SUCTION LIFT, 18.77 FEET.

10	6.21	236	239.1	277.1	85.1	310
10	6.21	236	241.2	279.6	84.4	325
15	6.226	236.6	254.4	294.8	80.2	----------
15	6.226	236.6	250	289.8	81.6	385
20	6.23	236.7	268.5	311.2	76	465
20	6.23	236.7	264.1	306.1	77.3	440
25	6.234	236.9	271.7	314.9	75.2	485
25	6.234	236.9	271.7	314.9	75.2	490
30	6.256	237.7	302.2	350.2	67.8	550
30	6.256	237.7	302.2	350.2	67.8	555
30	6.256	237.7	303.6	352.1	67.5	570
35	6.46	245.5	350.2	405.9	60.4	725
35	6.46	245.5	340.5	394.7	62.2	765
40	6.024	225.7	365.7	423.9	54	830
40	6.024	225.7	355.9	422.1	55.5	----------
40	6.024	225.7	364.6	422.6	54.1	870
40	6.024	225.7	364.6	422.6	54.1	----------

TOTAL LIFT, 37.96 FEET; SUCTION LIFT, 24.77 FEET.

10	6.11	231.9	240.1	278.3	83.3	290
10	6.11	231.9	241.2	279.6	82.9	285
15	6.154	233.6	250	289.8	80.6	310
15	6.154	233.6	248.9	288.5	80.9	305
20	6.15	233.5	258.7	299.9	77.8	345
20	6.15	233.5	268.4	311.1	75	365
20	6.15	233.5	269.5	312.3	74.7	370
20	6.15	233.5	273.8	317.4	73.5	375
20	6.15	233.5	259.8	301.1	77.5	345
25	5.996	227.6	291.7	338	67.3	425
25	5.996	227.6	291.5	337.8	67.3	500
25	5.996	227.6	286	331.5	68.6	415
25	5.996	227.6	287.1	332.8	68.4	525
25	5.996	227.6	292.8	339.3	67	405
30	5.73	213.7	279.5	323.9	65.9	585
30	5.73	213.7	270.7	313.8	68.1	475

TOTAL LIFT, 38 FEET; SUCTION LIFT, 30.85 FEET.

10	3.71	141	178.3	206.6	68.2	265
10	3.71	141	178.3	206.6	68.2	265
15	3.45	131.1	165.2	191.5	68.4	265
15	3.45	131.1	175	202.8	64.6	265
20	1.59	60.4	116.8	135.4	44.6	270
20	1.59	60.4	125	144.9	41.7	270
25	.516	19.6	96	113.9	17.21	270
25	.516	19.6	102.6	118.9	16.4	275
30	.14	5.32	109.8	127.2	4.1	285
30	.14	5.32	81.1	94	5.6	295

FRIZELL PUMP.

Fig. 23 represents a piston pump having a valve chamber surrounding the cylinder, and containing eight small clack discharge valves.

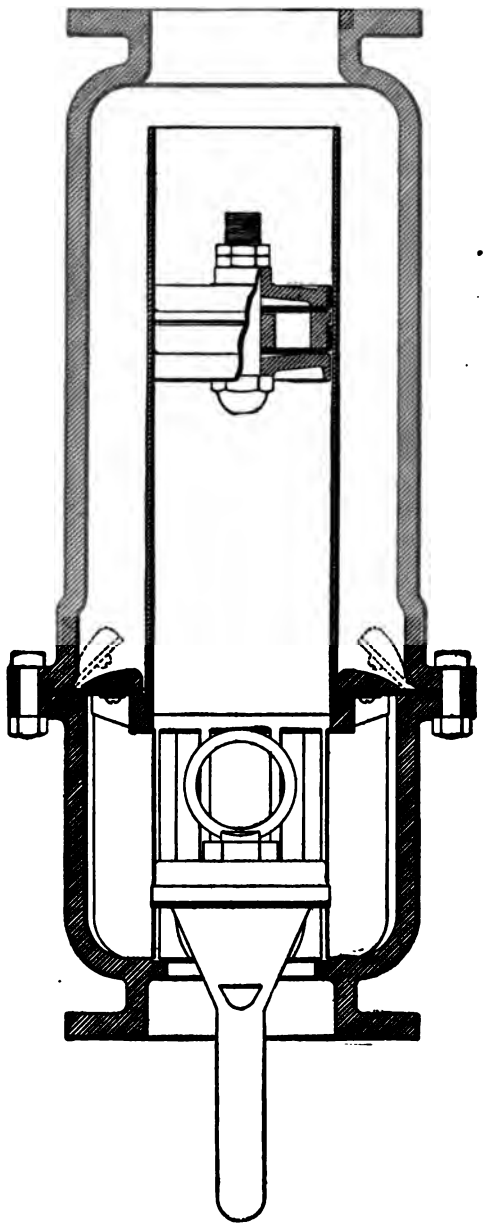


FIG. 23.—Vertical section of piston pump with valve chamber surrounding cylinder.

The suction valve is a heavy disk valve, playing in a special suction chamber, guided at its circumference, and not limited in its rise. It

is arranged to withdraw through the cylinder if necessary. On the upstroke water is drawn into the cylinder through the suction valve;

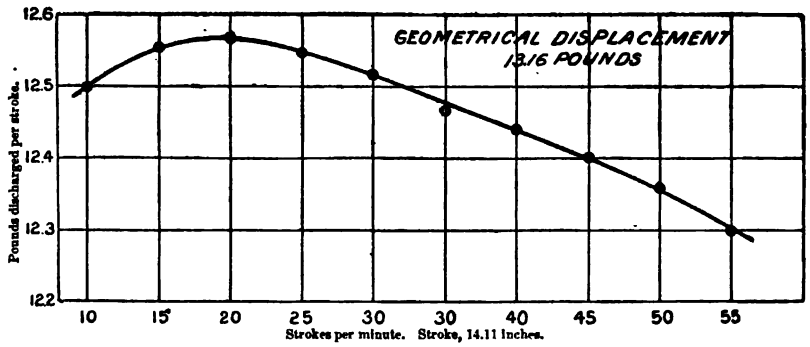


FIG. 24.—Discharge curve of 6-inch Frizell pump.

on the downstroke this water is forced through the delivery valves into the space above the piston, and is lifted on the next upstroke.

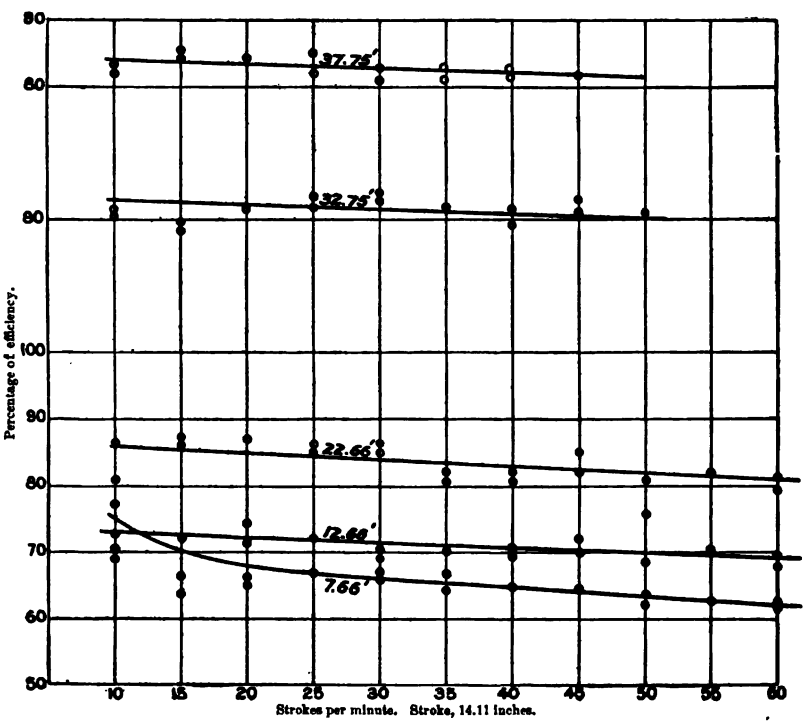


FIG. 25.—Varying-efficiency curves of 6-inch Frizell pump, showing effect of varying height of lift and speed.

The suction-valve area is 59½ per cent of the cylinder area; the cylinder diameter, 5.74 inches; the upper valve seat area, 29.7 inches, or

3.8 inches more than the cylinder area; the weight of the pump, 270 pounds, and the weight of piston, rod, etc., 62 pounds. This pump was designed especially for irrigation purposes, and is known as the "Frizell" pump. It is remarkable for its sustained efficiency at high speeds. So far as tested the speed was limited only by the ability of connections to stand the work. Fig. 24 gives the discharge per stroke, which reaches a maximum of 95½ per cent of the geometrical displacement. Fig. 25 shows efficiency curves for five lifts. The small dif-

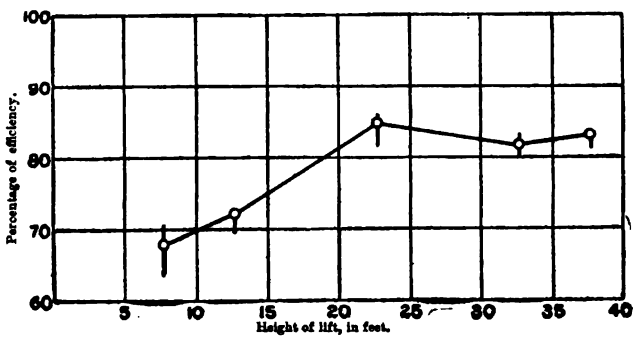


FIG. 26.—Variation of efficiency with varying height of lift of 6-inch Frizell pump at speed of 20 strokes per minute.

ference of efficiency at different speeds is due to the employment of large valve areas and small quick-closing valves. Fig. 26 shows that efficiency varies with the lift, being at its best probably at about 25 feet. The tables present the details of the tests.

Discharge of 6-inch Frizell pump at various lifts and speeds.

Speed.	Discharge in 30 strokes, lift 7.66 feet.	Discharge in 30 strokes, lift 12.66 feet.	Discharge in 30 strokes, lift 32.75 feet.	Plotted averages per stroke.
10	378	367	377	12.50
10	377		378	
15	377	371	380	12.56
15	379	371	383½	
20	377	373½	381½	12.57
20	378½	372½		
25	382	370	380	12.55
25		370	382	
30	375	366½	381½	12.52
30	379	369	376	
35	374	371	377½	12.47
35	371	365	374½	
40	379	370	379	12.44
40	375½	365½	374½	
45	374	365½	376	12.40
45	373	367	373	
50	377½–378	372	370½	12.36
50	380 –379	364	369	
50	371½–374			
55	363	364		12.30
55	371 –370	359		
60	372	361		12.22
60	371 –371	357		

Figures from efficiency tests of 6-inch Frizell pump; stroke, 19.. inches.

LIFT, 7.66 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum tension on rod.	Minimum tension on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*	*Pounds.*
10	12.50	95.75	106.37	124.11	77.1		
10	12.50	95.75	111.70	131.36	72.8		
15	12.56	96.21	124.45	146.35	66.4		
15	12.56	96.21	127.65	150.12	64.1		
20	12.57	96.28	124.45	146.35	65.7		
20	12.57	96.28	123.40	145.12	66.3		
25	12.55	96.13	122.35	143.88	66.8		
25	12.55	96.13	122.88	144.50	66.5		
30	12.52	95.90	123.40	145.12	66		
30	12.52	95.90	121.30	142.65	67.2		
35	12.47	95.52	121.30	142.65	66.9		
35	12.47	95.52	125.53	147.61	64.7		
40	12.44	95.29	125.53	147.61	64.5		
40	12.44	95.29	125.53	147.61	64.5		
45	12.40	94.98	125.53	147.61	64.3		
45	12.40	94.98	124.45	146.35	64.9		
50	12.36	94.68	126.56	148.84	63.6	800	—30
50	12.36	94.68	128.16	150.72	62.8		
55	12.30	94.22	128.16	150.72	62.5		
55	12.30	94.22	128.16	150.72	62.5		
60	12.22	93.60	128.16	150.72	62.1		
60	12.22	93.60	129.26	152	61.5		

LIFT, 12.66 FEET.

10	12.50	158.25	191.45	225.15	70.3	300	65
10	12.50	158.25	192.80	226.70	69.8		
15	12.56	159	186.95	220.25	72.1	310	40
15	12.56	159	187.75	220.79	72		
20	12.57	159.14	181.40	213.33	74.6		
20	12.57	159.14	189.35	223.67	71.4		
25	12.55	158.98	187.20	220.15	72.2		
25	12.55	158.98	188.55	221.74	71.7		
30	12.52	158.50	192.80	226.73	69.9		
30	12.52	158.50	191.45	225.15	70.3		
35	12.47	157.86	191.45	225.15	70.1		
35	12.47	157.86	191.45	225.15	70.1		
40	12.44	157.49	189.35	222.67	70.7		
40	12.44	157.49	191.45	225.15	69.9	750	—75
45	12.40	156.98	190.65	224.21	70	750	—80
45	12.40	156.98	185.10	217.68	72.1		
50	12.36	156.58	187.70	219.15	75.9		
50	12.36	156.58	194.44	228.66	68.4		
55	12.30	155.72	188.55	221.74	70.2	850	—70
55	12.30	155.72	188.55	221.74	70.2		
60	12.22	154.70	192.80	226.73	68.2		
60	12.22	154.70	189.35	222.67	69.4		

LIFT, 22.66 FEET.

10	12.50	283.25	277.50	326.34	86.7	410	60
10	12.50	283.25			80.6		
15	12.56	284.61	279.65	328.87	86.4		
15	12.56	284.61	277.50	326.34	87.2		
20	12.57	284.84	277.50	326.34	87.3		
20	12.57	284.84	277.50	326.34	87.3		
25	12.55	284.38	282.70	332.35	85.6		
25	12.55	284.38	280.60	329.98	86.2		
30	12.52	283.70	282.70	332.35	85.3	500	—85
30	12.52	283.70	284.80	334.92	84.4		
35	12.47	282.56	291.10	342.33	82.6		
35	12.47	282.56	295.35	347.33	81.3		
40	12.44	281.89	295.35	347.33	81	770	—85
40	12.44	281.89	291.10	342.33	82.3		
45	12.40	280.98	291.10	342.33	81.8		
45	12.40	280.98	284.80	332.12	84.6	930	—50
50	12.36	280.08	294.40	346.12	80.9	925	—100
50	12.36	280.08	295.35	347.33	80.6		
55	12.30	278.72	292.10	343.39	81.1		
55	12.30	278.72	291.10	342.33	81.4	1,050	—100
60	12.22	276.90	290.25	341.34	81.1		
60	12.22	276.90	296.20	348.33	79.4		

Figures from efficiency tests of 6-inch Frizell pump; stroke, 19.1 inches—Continued.

LIFT, 32.75 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum tension on rod.	Minimum tension on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*	*Pounds.*
10	12.50	409.38	435.38	512	81.3		
10	12.50	409.38	431.25	507.15	80.7		
15	12.56	411.34	441.60	519.32	79.2		
15	12.56	411.34	444.90	523.20	78.6		
20	12.57	422.06	440.40	517.91	81.5		
20	12.57	422.06	441.60	591.32	81.7		
25	12.55	421.41	429	504.50	83.5		
25	12.55	421.41	435.38	512	82.1		
30	12.52	420.43	425.85	500.90	83.9	720	—90
30	12.52	420.43	431.25	507.15	82.9		
35	12.47	408.39	424.42	499.12	81.8		
35	12.47	408.39	424.42	499.12	81.8		
40	12.44	407.41	430.80	506.62	81.3		
40	12.44	407.41	435.08	510.42	79.8	1,050	—97.5
45	12.40	406.10	425.20	500.04	81.1	1,027.5	—90
45	12.40	406.10	419.47	493.29	82.9		
50	12.36	404.79	425.20	500.04	80.9		
50	12.36	404.79	425.20	500.04	80.9	1,260	—60

LIFT, 37.75 FEET.

10	12.50	471.87	484.25	573.97	82.2		
10	12.50	471.87	484.87	566.68	83.2		
15	12.56	474.14	478.72	562.97	85.3		
15	12.56	474.14	475.50	559.19	84.7		
20	12.57	474.52	476.62	560.40	84.6		
20	12.57	474.52	479.77	564.21	84.1		
25	12.55	473.76	493.52	579.20	81.7	750	0
25	12.55	473.76	486.22	561.79	84.8		
30	12.52	472.63	483	568	83.2		
30	12.52	472.63	495.75	583	81		
35	12.47	470.74	492.52	579.20	81.2		
35	12.47	470.74	483	568	82.8	1,020	—67.5
40	12.44	469.61	489.38	575.51	81.6		
40	12.44	469.61	486.22	571.79	82.3	1,005	—67.5
45	12.40	468.10	486.22	571.79	81.9		

In the smaller size of this same make, fig. 27, a single butterfly valve in the piston replaces the several small clack valves. The cylinder is

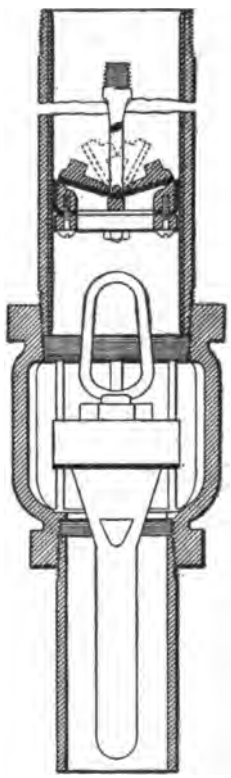


FIG. 27.—Vertical section of Frizell cylinder with butterfly valve.

brass-lined, is 3.73 inches in diameter, and has a 24-inch stroke. The valve area in the piston is 27.4 per cent of the cylinder area; the suc-

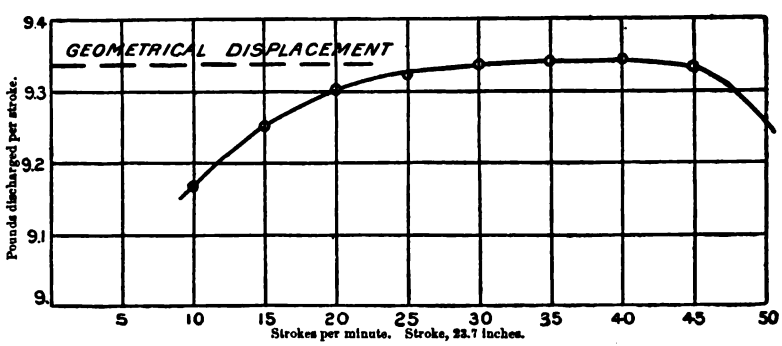


FIG. 28.—Discharge curve of 4-inch Frizell pump.

tion valve, 56 per cent; the weight of the pump, 57½ pounds, and the weight of piston, rod, etc., 39½ pounds. Fig. 28 shows a discharge

attaining to 100 per cent at speeds ranging from 25 to 40 strokes per minute. Fig. 29 shows the efficiency at six different lifts. The sustained efficiency of this pump is noticeable. In fig. 30 increase of efficiency with increase of lift appears. This pump is much used in Kansas for irrigation.

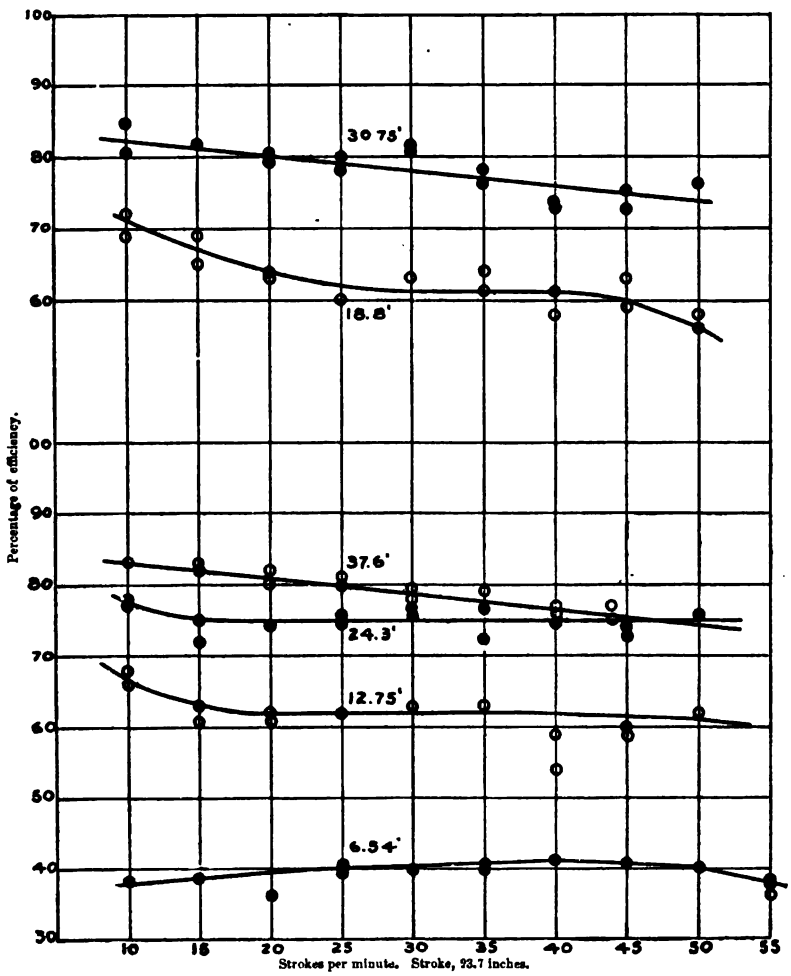


FIG. 29.—Varying-efficiency curves of 4-inch Frizell pump, showing effect of varying height of lift and speed.

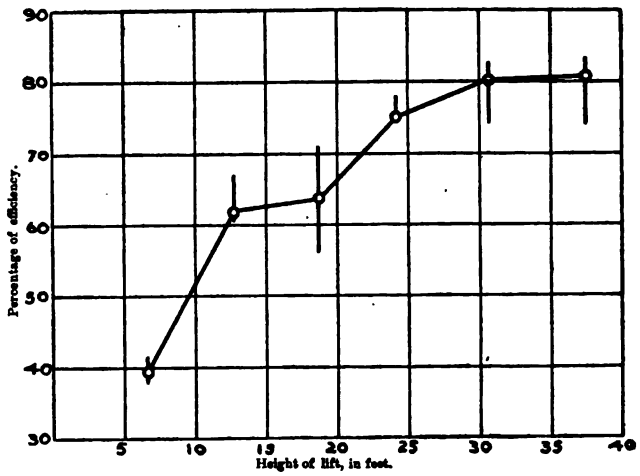


FIG. 30.—Variation of efficiency with varying height of lift of 4-inch Frizell pump at speed of 20 strokes per minute.

Discharges of 4-inch Frizell pump at various lifts and speeds; stroke, 23.7 inches.

Speed.	Discharge for 50 strokes; lift, 24.3 feet.	Discharge for 50 strokes; lift, 24.8 feet.	Discharge for 50 strokes; lift, 37.8 feet.	Discharge for 30 strokes; lift, 12.75 feet.	Discharge for 30 strokes; lift, 6.54 feet.	Plotted average discharge per stroke.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	
10	----------	451.5	463	275.5	274	9.168
10	----------	457.5	465	275.5	274	----------
15	460	463.5	466	275.5	277	9.25
15	----------	464	468	275.5	278.5	----------
20	465	464.5	467	278	281	9.302
20	----------	464	468	278	281.5	----------
25	467	463.5	467	278.5	280	9.322
25	----------	468.5	467.5	278.5	280	----------
30	466	469	467	279.5	279	9.334
30	----------	465	467	279.5	280	----------
35	472	468	468	279.5	281	9.34
35	----------	463.5	466.5	281	280.5	----------
40	467	466.5	466	281	284	9.42
40	----------	466.5	467	280.5	280	----------
45	467	462.5	467.5	280.5	280	9.332
45	----------	465	467.5	280	283	----------
50	----------	449.5	443	277.5	279	9.254
50	----------	----------	----------	279	279	----------
55	----------	----------	----------	171	253	----------
55	----------	----------	----------	----------	267	----------

Figures from efficiency tests of 4-inch Frizell pump; stroke, 23.7 inches.

LIFT, 6.54 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum tension on rod.	Minimum tension on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*	*Pounds.*
10	9.168	59.96	79.38	156.77	38.2	120	33
10	9.168	59.96	79.99	158.01	37.9		
15	9.2592	60.56	79.15	156.33	38.7		
15	9.2592	60.56	78.96	155.94	38.8		
20	9.2724	60.64	84.31	161.51	36.4	135	9
20	9.2724	60.64	83.75	165.41	36.6		
25	9.31	60.89	77.91	153.81	39.6		
25	9.31	60.89	76.04	150.18	40.5		
30	9.327	61.00	76.66	151.40	40.2	177	9
30	9.327	61.00	77.91	153.87	39.9		
35	9.34	61.08	75.82	149.74	40.7		
35	9.34	61.08	77.08	152.23	40.0	195	6
40	9.35	61.18	75.00	148.11	41.2	201	— 15
40	9.35	61.18	75.00	148.11	41.2		
45	9.33	61.04	76.23	150.55	40.5	253.5	— 30
45	9.33	61.04	76.65	151.38	40.3		
50	9.25	60.53	75.82	149.74	40.4	249	— 24
50	9.25	60.53	78.75	155.50	39.9		
55	8.66	56.68	75.82	149.44	37.8	222	— 30
55	8.66	56.68	75.41	148.90	38.0		

LIFT, 12.75 FEET.

10	9.168	116.89	89.63	177.00	66		
10	9.168	116.89	87.07	171.97	68		
15	9.260	118.05	94.90	187.43	63		
15	9.260	118.05	98.20	193.11	61		
20	9.270	118.22	97.17	191.91	61		
20	9.270	118.22	95.77	189.24	62		
25	9.310	118.70	97.22	192.00	62	175	30
25	9.310	118.70	96.60	190.78	62		
30	9.327	118.91	94.63	186.88	63		
30	9.327	118.91	97.30	184.82	63		
35	9.340	119.08	95.22	188.09	63		
35	9.340	119.08	96.45	190.78	63	250	11.5
40	9.350	119.17	109.85	216.95	54		
40	9.350	119.17	100.70	198.88	59		
45	9.330	118.99	99.57	196.66	60	325	— 11.5
45	9.330	118.99	101.40	200.26	59		
50	9.250	117.99	95.77	189.24	62	350	— 95
50	9.250	117.99	96.90	191.54	62		
55	5.700	72.67	99.30	196.11	37	375	— 75

LIFT, 18.8 FEET.

10	9.168	172.36	126.75	250.33	69	180	36
10	9.168	172.36	120.33	237.65	72		
15	9.260	174.07	135.21	267.04	65		
15	9.260	174.07	133.50	263.66	69		
20	9.270	174.32	139.05	274.62	63		
20	9.270	174.32	136.89	270.35	64		
25	9.310	175.03	148.32	292.93	60	240	24
25	9.310	175.03	142.83	282.09	62		
30	9.327	175.35	139.47	275.45	63		
30	9.327	175.35	139.47	275.45	63		
35	9.340	175.59	141.90	280.25	64	288	3
35	9.340	175.59	145.32	287.00	61		
40	9.350	175.86	146.64	289.61	61	336	6
40	9.350	175.86	151.68	299.56	58		
45	9.330	175.45	150.42	297.08	59	360	— 9
45	9.330	175.45	138.57	278.67	63		
50	9.250	173.98	154.62	305.37	56	405	— 30
50	9.250	173.98	151.26	299.49	58		
55	5.700	107.16	150.42	297.08	36	450	—120
55	5.700	107.16	156.32	308.75	34		
58	5.430	102.14	159.72	315.36	32	450	—120
58	5.430	102.14	156.33	308.75	33		

Figures from efficiency tests of 4-inch Frizell pump; stroke, 23.7 inches—Continued.

LIFT, 24.8 FEET.

Speed.	Discharge per stroke	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum tension on rod.	Minimum tension on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*	*Pounds.*
10	9.168	227.36	149.28	294.82	77.1		
10	9.168	227.36	147.48	291.27	78.0		
15	9.260	229.65	161.28	377.69	72.3		
15	9.260	229.65	155.01	306.06	75.3		
20	9.270	229.89	155.82	307.74	74.7		
20	9.270	229.89	156.66	309.40	74.3		
25	9.310	230.89	156.66	309.40	74.6		
25	9.310	230.89	154.14	304.34	75.8		
30	9.327	231.11	154.14	304.32	75.8	348	— 36
30	9.327	231.11	152.46	301.10	76.7		
35	9.340	231.63	154.14	304.42	76.8		
35	9.340	231.63	162.48	319.23	72.5		
40	9.350	231.88	157.59	311.24	74.4	398	— 24
40	9.350	231.88	158.73	312.65	74.1		
45	9.330	231.38	161.10	319.00	72.5	471	— 36
45	9.330	231.38	158.73	312.65	74.0		
50	9.250	229.40	153.99	304.13	75.4		

LIFT, 30.75 FEET.

10+	9.168	280.89	176.45	348.50	80.5	250	15
10+	9.168	280.89	175.05	345.70	81.2		
10	9.168	280.89	176.00	347.80	80.7	240	40
10	9.168	280.89	167.60	331.00	84.8		
15	9.26	284.72	176.55	348.70	81.6		
15	9.26	284.72	176.55	348.70	81.6		
20	9.27	285.12	179.25	354.00	80.5	280	40
20	9.27	285.12	181.15	357.80	79.3		
25	9.31	286.29	180.65	356.80	80.2		
25	9.31	286.29	184.85	365.10	78.1		
30	9.327	286.81	180.15	355.80	80.6	370	0
30	9.327	286.81	177.35	350.30	81.8		
35	9.34	287.20	190.15	375.60	76.4	425	0
35	9.34	287.20	185.90	367.20	78.2		
40	9.35	287.65	197.45	390.00	73.7	490	— 25
40	9.35	287.65	198.60	392.20	73.3		
45	9.33	286.98	199.70	394.40	72.7	540	— 5
45	9.33	286.98	193.25	381.70	75.1		
50	9.25	284.58	188.70	372.70	76.3	590	—125

LIFT, 37.6 FEET.

10	9.168	344.61	208.32	411.35	83		
10	9.168	344.61	208.32	411.35	83		
15	9.26	348.14	213.30	421.26	82	275	50
15	9.26	348.14	211.56	417.84	83		
20	9.27	348.64	214.98	424.58	82		
20	9.27	348.64	220.74	435.93	80		
25	9.31	350.06	220.74	435.93	80	360	36
25	9.31	350.06	218.94	432.40	81		
30	9.327	350.70	224.16	442.70	79.4		
30	9.327	350.70	225.18	444.73	78		
35	9.34	351.18	224.34	443.07	79	410	0
35	9.34	351.18	231.00	456.22	77		
40	9.35	351.73	231.66	457.38	76		
48	9.33	350.91	229.56	453.38	77		
48	9.33	350.91	234.30	462.89	75		

This pump was arranged as a force pump, as shown in fig. 1 (p. 12), and tested at three different lifts, as shown in fig. 31. At a lift of about 24 feet the efficiency is seen to be reduced from about 75 per cent to about 52 per cent upon the addition of a stuffing box and two turns in the discharge pipe. This drop in the efficiency exhibits the harmful effect of added complications. The gland was carefully made, and as lightly packed as possible, to prevent leakage. Adding

this reduction of about 20 per cent to the efficiencies found for the two high lifts of 47 and 70 feet, respectively, the efficiency of the pump

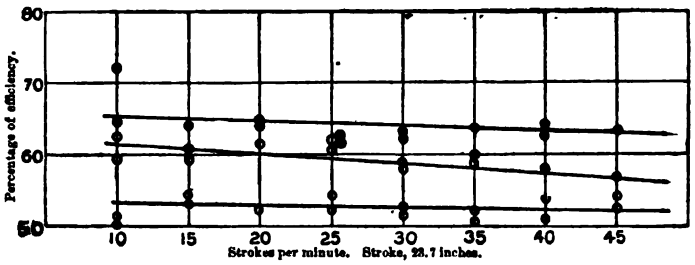


FIG. 31.—Efficiency of 4-inch pump used as a force pump.

when used as a simple lift pump, as in the first trials, is brought up to the neighborhood of 80 per cent.

Figures from efficiency tests of 4-inch Frizell pump, used as a force pump with a stuffing box; stroke, 23.7 inches.

LIFT, 24.3 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum tension on rod.	Minimum tension on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*	*Pounds.*
10	9.168	222.48	221.08	436.63	51.2	280	24
10	9.168	222.48	225.52	445.40	50		
15	9.260	225.02	223.32	441.06	53.2		
15	9.260	225.02	218.88	432.28	54.4		
20	9.270	225.26	217.76	430.07	52.3		
20	9.270	225.26	218.88	432.28	52.1		
25	9.310	226.32	211.08	416.88	54.2	308	—32
25	9.310	226.32	217.76	430.07	52.6		
30	9.327	226.60	217.56	429.56	52	376	—32
30	9.327	226.60	216.60	427.78	52.9		
35	9.340	227.12	221.08	436.63	52.1		
35	9.340	227.12	220.96	448.56	50.6		
40	9.350	229.55	217.68	449.08	51.1		
40	9.350	229.55	215.44	425.47	53.9		
45	9.330	224.69	215.44	425.47	52.8	520	—88
45	9.330	224.69	213.44	431.82	52.3		

Frizell 4-inch pump; stroke, 23.7 inches; used as a force pump and delivering water against air pressure equivalent to the lift noted.

LIFT, 47.37 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum tension on rod.	Minimum tension on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*	*Pounds.*
10	9.168	434.29	348.60	695.78	62.4		
10	9.168	434.29	369.60	729.96	59.4		
15	9.26	438.60	376.20	734.66	59.7		
15	9.26	438.60	360.30	711.59	61.6		
20	9.27	439.21	361.32	713.61	61.5		
20	9.27	439.21	360	711	61.7	444	— 18
25	9.31	441.01	366.66	724.16	60.9		
25	9.31	441.01	360	711	62		
30	9.327	441.82	378.30	747.14	59.1		
30	9.327	441.82	383.58	757.48	58.3		
35	9.34	442.44	380.33	751.15	58.9	636	—108
35	9.34	442.44	380	750.50	58.9		
40	9.35	442.90	385.44	761.23	58.1		
40	9.35	442.90	385.32	761	58.2		
45	9.33	441.96	402.24	794.34	56.9	756	— 90
45	9.33	441.96	413.32	816.30	54.1		

Frizell 4-inch pump; stroke, 23.7 inches; used as a force pump and delivering water against air pressure equivalent to the lift noted—Continued.

LIFT, 70.5 FEET.

Speed.	Discharge per stroke..	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum tension on rod.	Minimum tension on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*	*Pounds.*
10	9.168	646.34	495.75	895.77	72.1		
10	9.168	646.34	510	1,007	64.5		
15	9.26	652.83	515.33	1,101.11	59.2		
15	9.26	652.83	514.50	1,016.22	64.2		
20	9.27	653.54	508.35	1,008.90	65		
20	9.27	653.54	513.22	1,013.62	64.4		
25	9.31	656.36	536.25	1,059.09	61.9		
25	9.31	656.36	534.15	1,054.96	62.2		
30	9.327	657.55	532.13	1,050.95	62.5		
30	9.327	657.55	527.85	1,042.50	63		
35	9.34	658.47	521.53	1,030.02	63.8	780	— 75
35	9.34	658.47	515.33	1,101.11	59.8		
40	9.35	659.18	532.13	1,050.96	62.7		
40	9.35	659.18	516.66	1,020.32	64.6	825	—165
45	9.33	657.77	525.60	1,038.06	63.3		
45	9.33	657.77	525.60	1,038.06	63.3		

VAN VOORHIS PUMP.

Fig. 32 is a pump specially designed for slow speeds and low lifts, yet capable of running at high speeds. It is locally known in Kan-

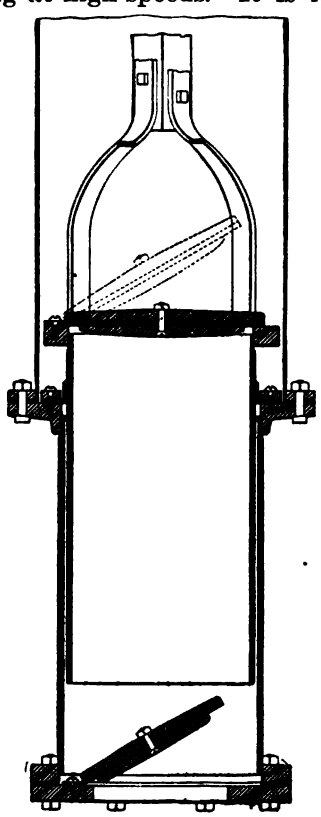


FIG. 32.—Vertical section of pump designed for slow speeds and low lifts.

sas as the Van Voorhis pump. The piston is replaced by a hollow plunger the upper opening of which is covered by a large clack valve. The plunger is packed with a suitable cup leather on the outside.

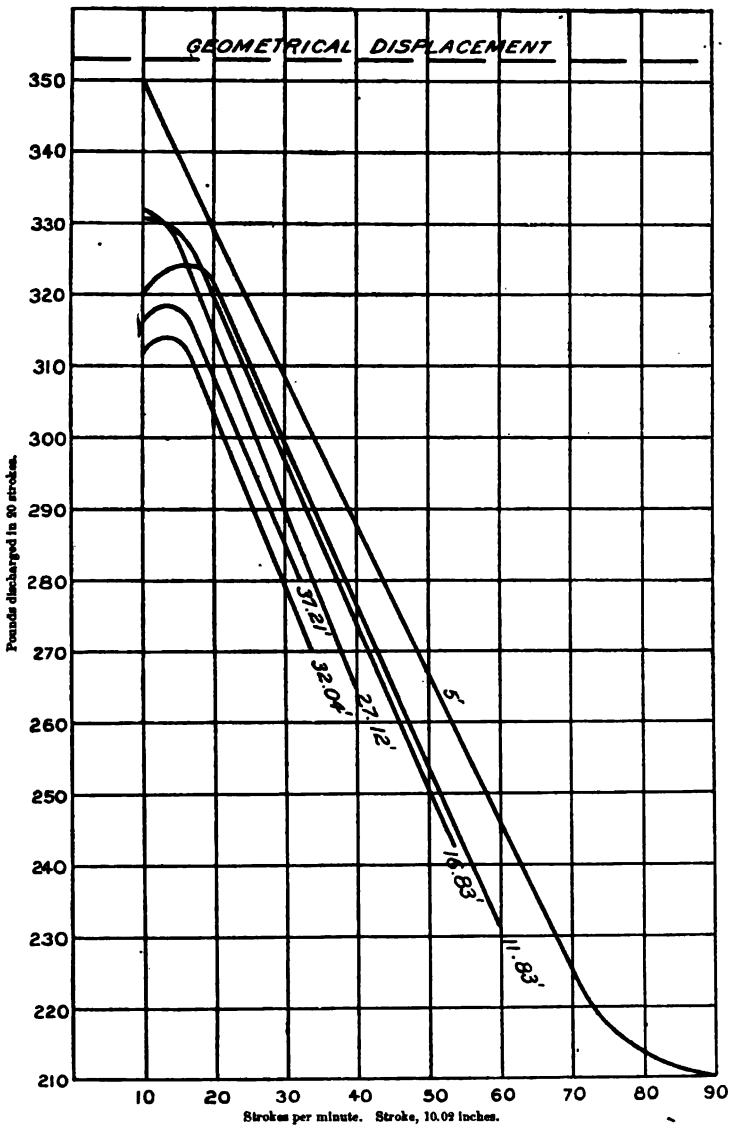


FIG. 33.—Varying-discharge curves of 8-inch Van Voorhis pump, showing effect of varying lift and speed.

The suction valve also is a large clack valve. The valve area is very great, being 70 per cent for the lower valve and 94 per cent for the upper valve in an 8-inch pump. The weight of the pump was 146 pounds, and of the plunger, rod, etc., 101.5 pounds. This design has

many advantages for very slow running, which, however, quickly disappear when a moderate piston speed is reached. The discharge

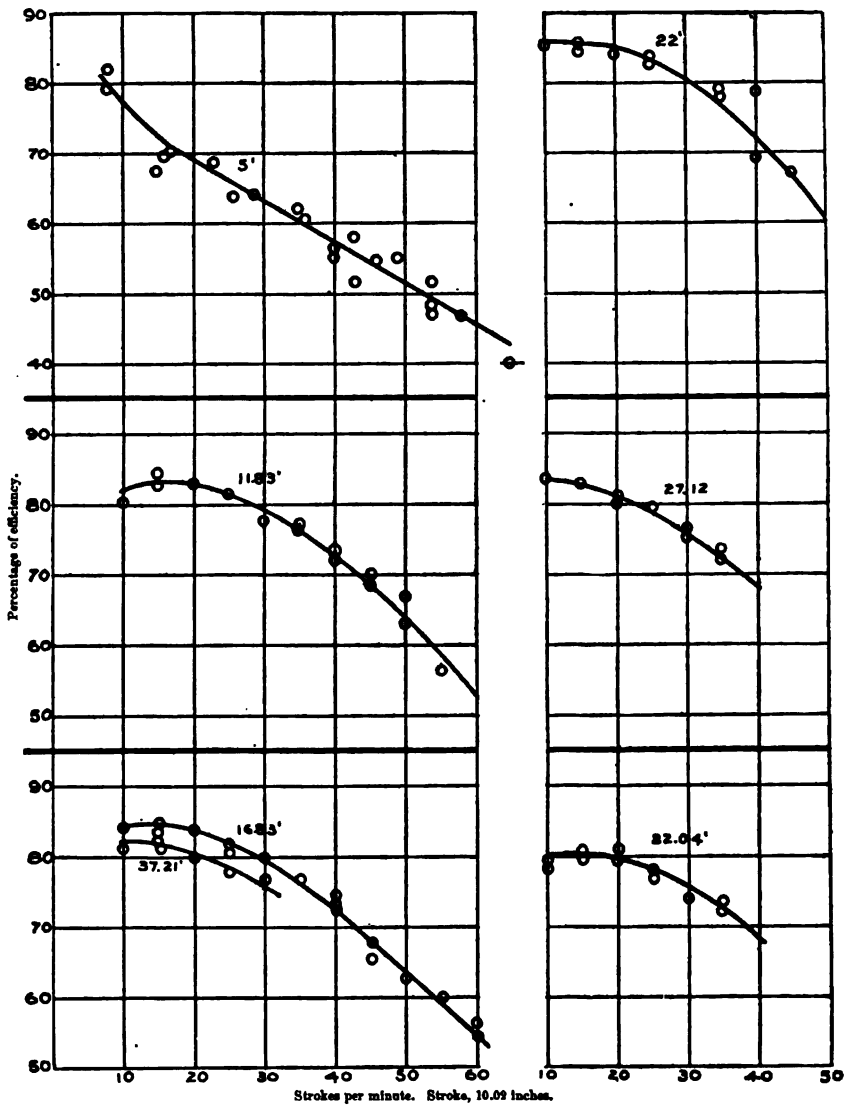


FIG. 34.—Varying-efficiency curves of 8-inch Van Voorhis pump, showing effect of varying lift and speed.

curves, shown in fig. 33, and varying for each lift, give the results for the large valves. Fig. 34 shows the efficiencies for six different lifts, and fig. 35 the change of efficiency with increase of lift.

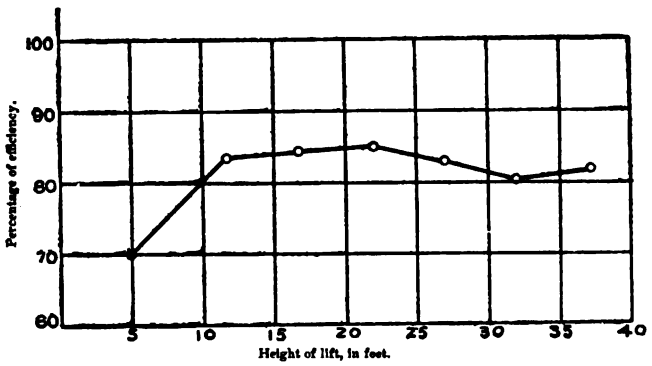


FIG. 35.—Variation of efficiency with varying height of lift of Van Voorhis pump at speed of 15 strokes per minute.

Discharge of Van Voorhis 8-inch pump at 5-foot lift; stroke, 10.02 inches.

Speed.	Discharge in 20 strokes.	Discharge in 20 strokes.	Plotted average; discharge per stroke.	Speed.	Discharge in 20 strokes.	Discharge in 20 strokes.	Plotted average; discharge per stroke
	Pounds.	*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*	*Pounds.*
10	348.5	348.5	17.55	50	262	259.5	13.35
15	344.5	346	17.06	55	249	253	12.80
20	332	328	16.50	60	244	241.5	12.35
25	315	315.5	15.97	65	227	235	11.80
30	301	296	15.42	68	220	238	11.35
35	296	294	14.85	70	222	219.5	11.05
40	289	290	14.30	75	221.5	220	10.90
45	281	291	13.77	80	213	215	10.67
47	373	.....	13.55	85	215.5	208.5	10.55

Discharge of Van Voorhis 8-inch pump at various lifts and speeds.

Speed.	Discharge, in pounds, for 20 strokes for lift:				
	11.83 feet.	16.83 feet.	27.12 feet.	32.04 feet.	37.21 feet.
10	320.5	328	331	306	316.5
10	318.5	332.5	332.5	308	315.5
15	323	329.5	329.5	313	319
15	325.5	328	326	317.5	318
20	326.5	320.5	317.5	298	309
20	322.5	321	315	302.5	309
25	309.5	306.5	300	293	299
25	308.5	310.5	300.5	290.5	296
30	294	297	288.5	290	280.5
30	301.5	301	286	282.5	288.5
35	290	284.5	285	.....	.....
35	290.5	286	284	.....	.....
40	275.5	256	.....	.....	.....
40	270.5	275	.....	.....	.....
45	272.5	243	.....	.....	.....
45	267.5	251	.....	.....	.....
50	257.5	.....	.....	.....	.....
50	249.5	.....	.....	.....	.....
55	247.5	.....	.....	.....	.....
55	239	.....	.....	.....	.....
60	232.5	.....	.....	.....	.....
60	223.5	.....	.....	.....	.....

Plotted average discharge per stroke.

Speed.	Discharge, in pounds, per stroke for lift:					
	11.83 feet.	16.83 feet.	22 feet.	27.12 feet.	32.04 feet.	37.21 feet.
10	15.975	16.525	16.562	16.6	15.55	15.8
15	16.1	16.45	16.412	16.375	15.7	15.925
20	16.05	16	15.887	15.775	15.2	15.45
25	15.575	15.425	15.275	15.125	14.575	14.85
30	15	14.85	14.675	14.5	14	14.25
35	14.425	14.3	14.1	13.9	13.35	
40	13.85	13.725	13.487	13.25		
45	13.275	13.175	12.912	12.65		
50	12.7	12.6	12.3	12		
55	12.125	12.05				
60	11.55	11.5				

Figures from efficiency tests of 8-inch Van Voorhis pump; stroke, 10.02 inches.

LIFT, 4.875 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds work given to rod.	Mechanical efficiency.	Maximum tension on the rod.	Minimum tension on the rod.	Stroke finished at closure of the upper valve.	Stroke finished at closure of the lower valve.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*
8	17.65	86.04	130	108.55	79.20	235	+ 85		
8	17.65	86.04	125.50	104.79	82.10				
35	14.85	72.39	140.95	117.68	62			4	12
40	14.30	69.71	147.65	123.28	56	515	+ 20	5	16
40	14.30	69.71	151	126	55.30			5	16
54	12.80	62.40	158.30	132.18	47.20	780	− 50	11	21
54	12.80	62.40	156.65	131.63	47.40			11	21
54	12.80	62.40	155.30	129.67	48.20			11	21
54	12.80	62.40	157.70	131.69	47.30	675	− 35	11	21

LIFT, 5.166 FEET.

15	17.05	88.09	154.30	128.84	67.60				2
16	16.95	87.57	150.80	125.90	69.55				3
17	16.85	86.96	148.65	124.12	70				5
20	16.50	85.25	150	125.25	68	285	40		6
23	16.20	83.70	145.70	121.66	68.80	280	50	.6	6
26	15.85	81.89	153.30	128	63.97			.9	9
29	15.50	80.08	150	125.25	63.92			2	11
36	14.75	76.20	150	125.25	60.80	490	0	4	15
36	14.75	76.20	151.30	126.33	60.30			4	15
43	14	72.33	167.75	140.07	51.60	550	0	6	16
43+	13.90	71.81	147.65	123.28	58.20			6	17
46	13.65	70.52	154.30	128.67	54.80	575	15	7	19
43+	13.90	71.81	147.65	123.28	58.20			5	17
49	13.35	68.97	150	125.25	55			5	20
54	12.80	66.13	153.30	128	51.60	650	0	10	21
54	12.80	66.13	153.30	128	51.60			10	22
58	12.35	63.81	164.04	136.89	46.60	876	− 72	12	22
65	11.60	59.93	179.46	149.84	40	600	0	12	
72	11.05	55.25	194.32	162.25	34	1,200	− 75	17	27
84	10.55	54.51	285.30	238.22	22.80			20	
85	10.50	54.24	226.16	188.64	27.80	1,500	−150	21	32
90	10.40	53.73	264.12	220.37	24.70	1,200	−160	20	
100	10	50	283.72	236.90	21.10	1,560	−185	22	

Figures from efficiency tests of 8-inch Van Voorhis pump; stroke, 10.02 inches—Continued.

LIFT, 11.83 FEET.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum tension on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*
10	15.975	188.9	281.1	235.8	80.5	417
10	15.975	188.9	281.1	235.8	80.5	422
15	16.1	190.4	276	230.2	82.7	427
15	16.1	190.4	269.9	225.4	84.5	437
20	16.05	189.8	274	228.8	82.9	475
20	16.05	189.8	273.7	228.5	83	500
25	15.575	184.3	272.5	226.9	81.2	525
30	15	177.4	272.4	227.4	78	660
30	15	177.4	266.2	222.3	79.8	720
35	14.425	170.6	264.6	221	77.2	750
35	14.425	170.6	266.9	222.9	76.5	780
40	13.85	163.8	272.2	227.3	72	1,060
40	13.85	163.8	266.9	222.8	73.5	895
45	13.275	157	274.5	229.2	68.5	1,070
45	13.275	157	268.4	224.1	70	1,015
50	12.7	150.2	269.1	224.7	66.8	1,135
50	12.7	150.2	285.4	238.2	63	1,265
55	12.125	143.4	303.9	253.7	56.5	1,410
55	12.125	143.4	303.9	253.7	56.5	1,380
60	11.55	136.6	308.5	257.6	53	1,357
60	11.55	136.6	303.2	259.5	52.6	1,432

LIFT, 16.83 FEET.

10	16.525	278.1	395.8	330.5	84.1	565
10	16.525	278.1	396.6	331.2	83.9	565
15	16.45	276.8	394.7	329.6	84.1	595
15	16.45	276.8	391.2	326.6	84.7	590
20	16	269.3	386.6	322.8	83.4	650
20	16	269.3	387.3	323.4	83.2	650
25	15.425	259.6	383.8	320.5	81	710
25	15.425	259.6	380	317.3	81.8	710
30	14.85	249.9	375.3	313.4	79.7	875
30	14.85	249.9	374.6	312.8	79.9	----------
35	14.3	240.6	374.2	312.5	77	940
35	14.3	240.6	373.5	311.9	77.1	1,000
40	13.725	231	370.4	309.3	74.7	1,030
40	13.725	231	375.3	313.4	73.7	1,050
40	13.725	231	372.3	310.9	74.3	1,070
40	13.725	231	374.2	317.8	72.7	1,010
45	13.175	221.7	391	326.5	67.9	1,224
45	13.175	221.7	405.9	338.9	65.4	1,309
50	12.6	212	404.8	338	62.7	1,245
50	12.6	212	405.9	338.9	62.5	1,395
55	12.05	202.8	404.7	337.9	60	1,372
55	12.05	202.8	404.7	337.9	60	1,330
60	11.5	193.5	426.4	356.1	54.3	1,515
60	11.5	193.5	410.4	342.7	56.4	1,447

LIFT, 22 FEET.

10	16.562	364.3	510.8	426.5	85.4	720
10	16.562	364.3	510.1	425.9	85.5	715
15	16.412	361	504.7	421.4	85.6	770
15	16.412	361	510.8	426.5	84.6	740
20	15.887	349.5	497.7	415.6	84.1	855
20	15.887	349.5	492.2	411	85	890
25	15.275	336	486.8	406.5	82.6	945
25	15.275	336	480.7	401.4	83.7	----------
30	14.675	322.8	483.9	404	79.9	1,035
30	14.675	322.8	482.2	402.7	80.1	1,140
35	14.1	310.2	474.6	396.3	78.2	1,215
35	14.1	310.2	468.4	391.2	79.3	1,160
40	13.487	296.7	501.5	418.8	70.8	1,380
40	13.487	296.7	513.8	429	69.1	1,507
45	12.912	284	505.3	421.9	67.3	1,402
45	12.912	284	505.3	421.9	67.3	1,402
50	12.3	270.6	531.6	443.9	60.9	1,687
50	12.3	270.6	533.2	445.3	60.7	1,650

Figures from efficiency tests of 8-inch Van Voorhis pump; stroke 10.02 inches—Continued.

LIFT, 27.12 FEET.

Speed.	Discharge per stroke.	Foot pounds of useful work.	Average pull on rod.	Foot pounds of work given to rod.	Mechanical efficiency.	Maximum tension on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*
10	16.6	450.2	646.3	539.7	83.4	832
10	16.6	450.2	646.5	539.8	83.4	900
15	16.375	444.1	642.5	536.5	82.7	969
15	16.375	444.1	640.9	535.1	83	975
20	15.775	427.8	634.7	530	80.7	1,027
20	15.775	427.8	638.2	532.9	80.2	1,035
25	15.125	410.2	617.3	515.4	79.5	1,097
25	15.125	410.2	619.9	517.7	79.2	1,170
30	14.5	393.2	619.9	517.7	75.96	1,395
30	14.5	393.2	615.7	514.1	76.4	1,380
35	13.9	367	611.5	510.6	71.8	1,500
35	13.9	367	600	501	73.2	1,447

LIFT, 32.04 FEET.

10	15.55	498.2	760.4	634.9	78.4	1,057
10	15.55	498.2	760.4	634.9	78.4	1,080
15	15.7	503	753.5	629.2	79.9	1,132
15	15.7	503	746.5	623.3	80.7	1,110
20	15.2	487	734.9	613.6	79.3	1,252
20	15.2	487	721	602	80.9	1,350
25	14.575	467	725.6	605.9	77	1,320
25	14.575	467	718.9	600.2	77.8	1,440
30	14	448.5	724.5	604.9	74.1	1,455
30	14	448.5	712.1	594.5	75.4	1,447
35	13.35	427.7	706.2	589.6	72.5	1,567
35	13.35	427.7	696.3	581.4	73.5	1,567

LIFT, 37.21 FEET.

10	15.8	587.9	868	724.8	81.1	1,177
10	15.8	587.9	865.7	722.8	81.3	1,177
15	15.925	592.5	867.2	724.1	81.8	1,185
15	15.925	592.5	864.5	721.8	82	1,185
20	15.45	574.9	857.3	715.9	80.3	1,290
20	15.45	574.9	859.1	717.3	80.1	1,290
25	14.85	552.5	845.5	704.5	78.2	1,305
25	14.85	552.5	847.8	707.9	78	1,320
30	14.25	530.2	825.7	689.5	76.9	1,380
30	14.25	530.2	823.1	687.3	77.1	1,380

COOK PUMP.

The Cook cylinder, made by the Cook Well Company, of St. Louis, Missouri, has been developed especially for deep-well pumping, and the 4-inch size is shown in fig. 36. The design admits of the withdrawal of both the piston and the suction-valve device for inspection or repair. The actual diameter is 3.75 inches. Though furnished with double packing leathers and having a valve area of 21 per cent of the cylinder area, its efficiency in deep wells is notable. Both valves are rubber disks, guided by a central stem. The cylinder is brass lined and highly polished, and friction is thus greatly reduced. However, on account of the high pressures with which this pump deals, double cup leathers for packing are required, by which, on the other hand, friction is increased. Built especially for high lifts, it is not to

be expected that it will develop a high efficiency at the low lifts prevailing in irrigation work.

In testing this pump it was first operated in an open well with a 34.8-foot lift. The efficiency varied from about 78 to 58 per cent at

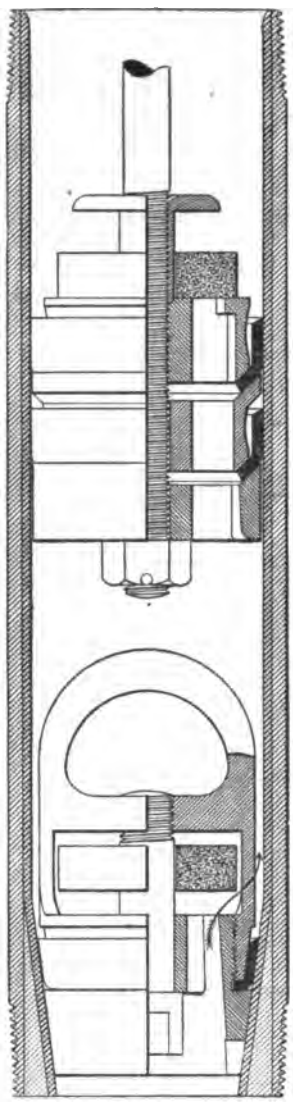


FIG. 36.—Vertical section of Cook cylinder.

speeds of 12 to 40 2-foot strokes per minute. The pump was then provided with a stuffing box, carefully made and packed, and was made to deliver water against an air pressure equivalent to the previous total lift of 34.8 feet.

The mean pull on the pump rod was found to be increased about 30 pounds by the friction in the stuffing box, and the efficiency, in

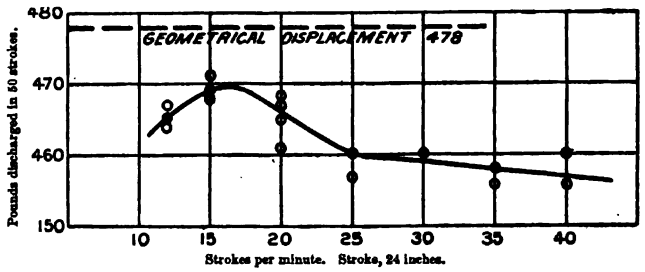


FIG. 37.—Discharge curve for 4-inch Cook deep-well pump.

consequence, lowered from the 78 to 58 per cent of the previous test to 67 to 53 per cent. At the higher lifts tried the same method was

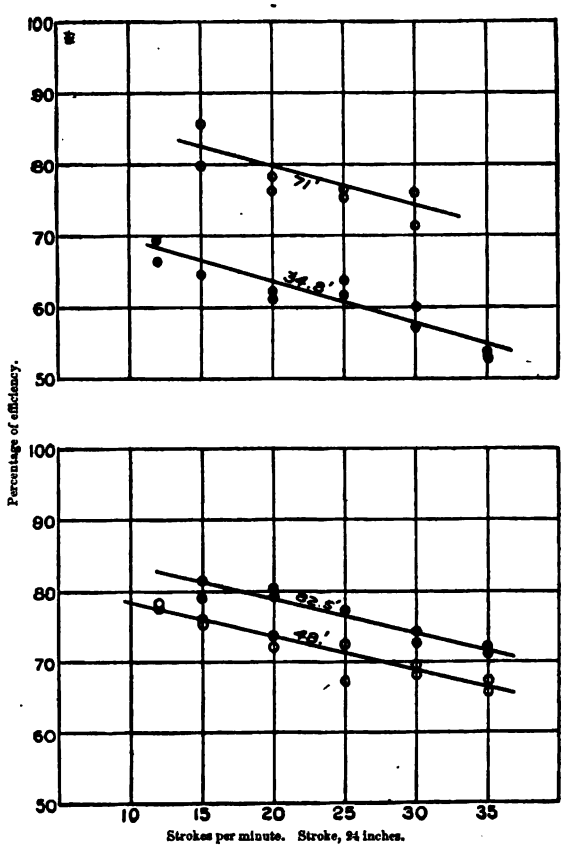


FIG. 38.—Varying-efficiency curves of 4-inch Cook pump, showing effect of varying lift and speed.

followed, and the efficiency, at an 82.5-foot lift and at speeds ranging from 15 to 35 strokes per minute, was found to range from 81 to 72

per cent. Allowing for the increase of friction resulting from the addition of a stuffing box, the efficiency of the pump in an open well and at the same depth would probably be 85 to 77 per cent. Fig. 37 gives the discharge curve, and fig. 38 the efficiency curves, at differing lifts, for this pump, fitted with the packed stuffing box and rod. There are exhibited a quick action of the valves, a remarkably low maximum stress, and slight compression in the pump rod at speeds above 20 strokes per minute.

There is here seen to be marked advantage in the special adaptation of parts to special conditions.

Discharge of 4-inch Cook pump; stroke, 24 inches.

Speed.	Experimental discharge per 50 strokes.	Plotted average discharge per stroke.	Speed.	Experimental discharge per 50 strokes.	Plotted average discharge per stroke.
	Pounds.	*Pounds.*		*Pounds.*	*Pounds.*
12	465	9.3	20	465	.....
12	464	.....	25	457	9.2
12	467	.....	25	460	.....
15	469	9.38	30	460	9.18
15	471	.....	30	460	.....
15	468	.....	35	458	9.16
15	468	.....	35	456	.....
20	468	9.32	40	456	9.14
20	461	.....	40	460	.....
20	467	.....			

Figures from efficiency tests of 4-inch Cook pump; stroke, 24 inches.

LIFT, 34.8 FEET; OPEN WELL.

Speed.	Discharge per stroke.	Foot-pounds of useful work.	Average pull on rod.	Foot-pounds of work given to rod.	Mechanical efficiency.	Maximum pull on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*
12	9.3	323.6	207.6	415.6	77.8	280
12	9.3	323.6	213.9	428.1	75.6	285
15	9.38	326.4	205.3	410.9	79.4	315
15	9.38	326.4	203.9	408.2	79.9	305
20	9.32	324.3	215.9	432.1	75	350
20	9.32	324.3	212.5	425.4	76.2	335
25	9.2	320.1	225.6	451.6	70.8	385
25	9.2	320.1	225.6	451.6	70.8	410
30	9.18	319.5	246.3	493	64.8	510
30	9.18	319.5	243.1	486.6	65.6	525
35	9.16	318.8	257.6	515.6	61.8	575
35	9.16	318.8	253.4	507.3	62.8	635
40	9.14	318.1	273	546.4	58.2	650
40	9.14	318.1	270.1	540.7	58.8	650

LIFT, 34.8 FEET, USING STUFFING BOX.

12	9.3	323.6	243.1	486.5	66.5	315
12	9.3	323.6	232.7	465.7	69.5	310
15	9.38	326.4	251.4	503.2	64.8	350
15	9.38	326.4	251.4	503.2	64.8	375
20	9.32	324.3	264.5	529	61.2	400
20	9.32	324.3	260.4	521.3	62.2	415
25	9.2	320.1	250	500.4	63.9	420
25	9.2	320.1	259.1	518.6	61.7	435
30	9.18	319.5	266.7	533.8	59.8	565
30	9.18	319.5	279.2	558.8	57.1	560
35	9.16	318.8	297.2	594.9	53.5	650
35	9.16	318.8	300	600.4	53	675

Figures from efficiency tests of 4-inch Cook pump; stroke, 24 inches—Continued.

LIFT, 48 FEET, USING STUFFING BOX.

Speed.	Discharge per stroke.	Foot pounds of useful work.	Average pull on rod.	Foot pounds of work given to rod.	Mechanical efficiency.	Maximum pull on rod.
	Pounds.		*Pounds.*		*Per cent.*	*Pounds.*
12	9.3	446.4	284.8	570.1	78.3	380
12	9.3	446.4	288.1	576.7	77.4	375
15	9.38	450.2	295.4	591.2	76.1	400
15	9.38	450.2	298.6	597.7	75.3	415
20	9.32	447.4	302.2	605	73.9	460
20	9.32	447.4	309.2	618 9	72.3	450
25	9.2	441.6	327.3	655.1	67.4	515
25	9.2	441.6	304.9	610.2	72.3	490
30	9.18	440.6	322.7	645.9	68.2	565
30	9.18	440.6	316.2	632.8	69.6	545
35	9.16	439.7	325.7	651.9	67.4	640
35	9.16	439.7	331.9	664.4	66.1	655

LIFT, 71 FEET, USING STUFFING BOX.

15	9.38	666	416.6	834	79.8	565
15	9.38	666	389.3	779.2	85.4	520
20	9.32	661.7	433.9	868.4	76.2	585
20	9.32	661.7	421.4	843.4	78.4	595
25	9.2	653.2	431.3	863.2	75.6	625
25	9.2	653.2	428.1	856.8	76.2	630
30	9.18	651.8	429	858.6	75.9	750
30	9.18	651.8	454.7	910.2	71.6	765

LIFT, 82.5 FEET, USING STUFFING BOX.

15	9.38	773.9	475	950.7	81.4	590
15	9.38	773.9	488.2	977.1	79.2	590
20	9.32	705	478.5	957.7	80.3	705
20	9.32	705	485.3	971.5	79.1	700
25	9.2	759	489.6	980	77.4	780
25	9.2	759	488.9	978.5	77.5	825
30	9.18	757.3	509.7	1,020	74.2	830
30	9.18	757.3	518.7	1,038	72.9	840
35	9.16	755.7	529.2	1,059	71.3	815
35	9.16	755.7	523.7	1,048	72.1	1,020

SUMMARY.

To pump large quantities of water with small power economically, it is necessary that the pump speed be slow, preferably below 20 strokes per minute; that the pump itself be large and of long stroke, and that the valve area be at least 30 per cent of the cylinder cross-section area.

For the more rapid-running pumps the valve area should be still larger.

The efficiency of pumps rightly called good pumps may vary from 20 to 85 per cent, depending on the lift and the piston speed.

A fall of 25 per cent in the efficiency of a pump in the usual range of windmill speed is not uncommon.

A pump having a variation of only 5 per cent is possible.

For wells about 20 feet deep there is no need for using a pump of less than 75 per cent efficiency for average speeds.

Two pumps may compare very favorably at a certain lift, and much less favorably at some other lift not greatly different.

A pump having an efficiency of over 80 per cent at piston speeds up to 100 feet per minute is possible at a 20-foot lift.

Some pumps can be run at a piston speed of 180 feet per minute and maintain an efficiency above 70 per cent for lifts above 20 feet.

A pump with very large clack valves, on a very low lift, may give an efficiency from 80 per cent at slow speed to 50 per cent at a piston speed of 80 feet per minute.

Pumps at slow speed and at high speed alike discharge a little less water per stroke than at medium speed—perhaps from 1 to 2 per cent.

A pump with small delivery pipe may at high speed deliver a considerably larger amount of water than that computed from the cylinder capacity.

With pumps having an ample supply of water the speed may be limited by failure of the lower valve if its movement is not limited.

Valves of limited movement are preferable for fast speeds.

The addition of a stuffing box to any form of pump may seriously reduce the efficiency.

The initial stress on the upstroke at the higher speeds is the destructive element in windmill operation. The use of a device for reducing this stress is well worth consideration. At piston speeds of only 70 feet per minute this sudden jerk may be equivalent to two or three times the weight of the column of water lifted.

A method of pump testing is possible which would determine the behavior of valves and give the measure of the resistances at various stages of the stroke in such manner as to admit of quantitative statement.

RESISTANCE TO ROTATION OFFERED BY VARIOUS CRANK-DRIVEN PUMPS.

The resistance offered to any driving mechanism by a single-cylinder pump varies greatly at different stages of the pump stroke. If connection with the pump be through the usual crank, the resistance offered by the crank will be slight at each dead center. Piston and rod, if of sufficient weight, will afford some motive power on the downstroke. The useful work is done during the upstroke, and the larger portion of it during the first part of the upstroke, excepting when the speed is very slow. In fig. 39 horizontal distances represent positions of the crank in its circular course during a single revolution. The position in each case is located from the lower dead center as an initial point. The heights of the vertical lines represent the resisting moment at that point. Neglecting the effect of angularity of the connecting rod, the smooth sinusoidal curve represents the resistances to turning, assuming the load to be uniform on the upstroke and to be diminished to about one-eighth on the downstroke. This diminished load is the weight of the piston, rod, etc. The shaded area above

the zero line represents the work done in raising the piston, rod, and water; and that below the line, from 180° to 360°, represents the work returned by the falling piston and rod on the downstroke. The outside line and the heavier-shaded portion show the actual resisting moments, as computed from the diagram, fig. 40, from the work of an 8-inch pump at a lift of 22 feet and a speed of 25 strokes per minute. The additional work required for acceleration of the water, etc.,

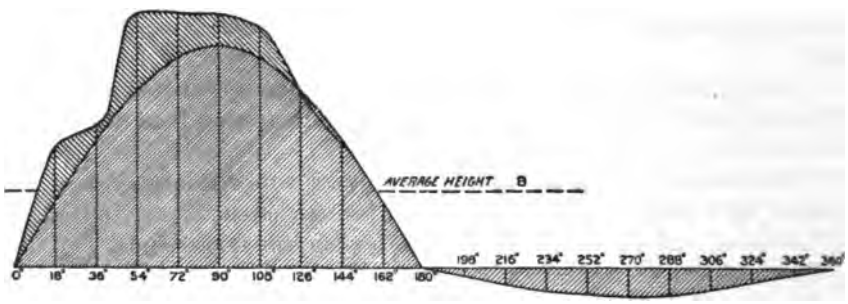


FIG. 39.—Diagram of resistance to rotation of crank driving a single-cylinder lift pump.

is shown by the heavier-shaded area. This great variation in the turning resistance renders it impossible, without considerable loss of efficiency, effectively to use certain forms of motors.

If a horse be used to operate a pump of this kind, by means of a sweep or other suitable turning device, during a stroke of the pump, he will meet with resistances such as shown by the vertical lines in fig. 39. The pump must not be so large that the maximum moment

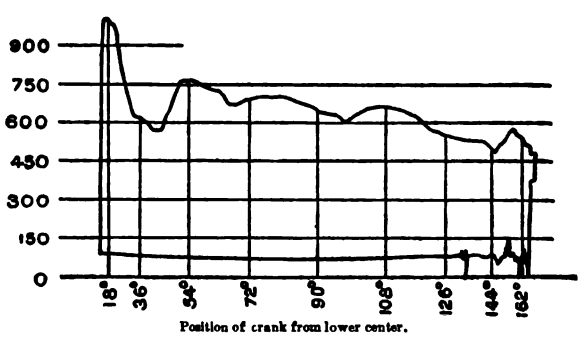


FIG. 40.—Dynamometer diagram of actual resistance at various positions of crank.

can not be reached and overcome at a point somewhere between 50° and 90° of the revolution. Even then, for at least half the time, the horse will be doing no work at all, and for 60 per cent of the time he will be loaded below the average. The line AB gives the average resistance. Furthermore, it appears that the maximum load reaches to more than three and one-half times that of the average load. This fault may be remedied in part by the use of a fly wheel of moderate

weight. The unevenness of loading will continue to be so considerable, however, as to render the work of the horse laborious; whereas with equalized load he could do even a larger amount of work with comparative ease. A windmill encounters the same difficulty, as may be seen from the ineffectual efforts it makes in light winds to pass

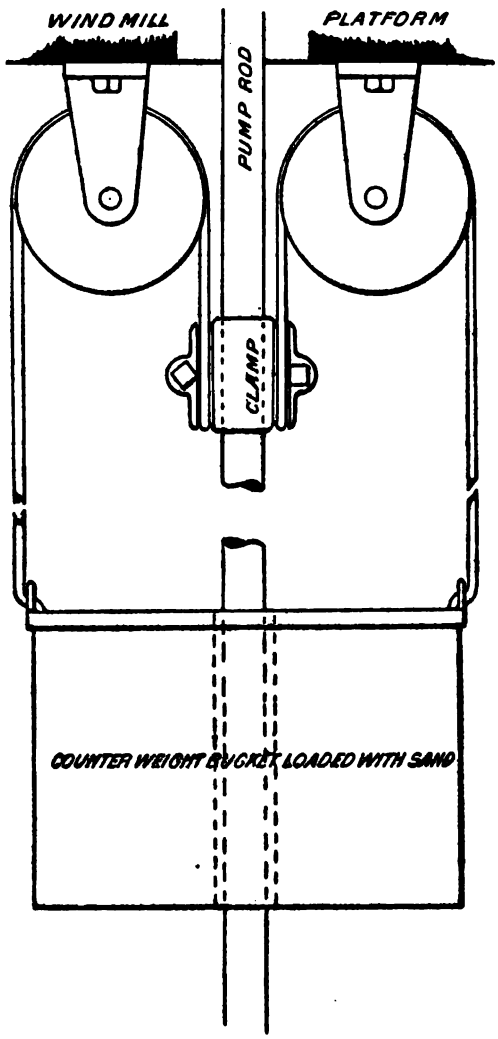


FIG. 41.—Method of counterbalancing a windmill pump.

this point of maximum load. It becomes apparent, too, that if the load were evenly distributed the mill would find the light wind power sufficient for light running. By the use of a counterweight a partial distribution at least can be effected.

A modification of the horse-power sweep sometimes to be seen is a wooden spring bar so attached as to offer a spring resistance during

the light-pull interval and to assist correspondingly on the heavy pull. It has decided merit. As applied to the pump rod of a windmill the modification might take the form of a weight encircling the rod and given a direction of motion opposite to that of the rod by means of pulleys, as shown in fig. 41. This device should be attached to back-geared mills only, and should have its range of action fixed so high in the tower as to leave the pump rod free to act in compression without bending. The counterweight should equal one-half that of the load on the piston and should range as low in the tower as practicable.

Differential pumps equalize the work between the upstroke and

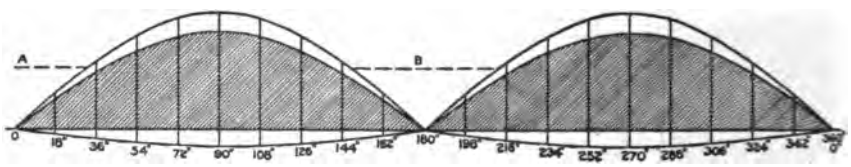


FIG. 42.—Diagram of resistance to rotation of a shaft carrying two cranks driving a duplex pump.

the downstroke by employing a very large piston rod. If the cross-section area of the piston rod be one-half that of the cylinder, one-half of the cylinder capacity will be discharged on the upstroke and the remaining half by displacement on the downstroke. Work is thus equalized between the upstroke and the downstroke. Since, however, the work required on the downstroke, which has now become in fact a down thrust, necessitates the use of stiff rods in order to avoid compressive bending, there is disadvantage in the practice where long rods are required, as in deep wells or for windmills with

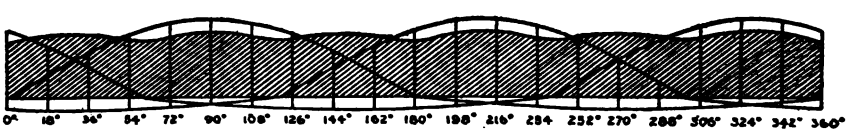


FIG. 43.—Diagram of resistance to rotation of a shaft carrying three cranks driving a triplex pump.

high towers. For such long thrust rods guides must be provided at frequent intervals to preserve the alignment and insure direct action, and frictional resistance is thus introduced.

Again, there will be enlargement of the pump rod for a short distance only at the water surface in the discharge pipe. This enlargement is partially withdrawn from the water on the upstroke, thereby vacating a space to be filled and thus reducing the discharge, and it is lowered into the water on the downstroke, thereby forcing upward an equal volume of water by displacement and thus compensating for the previous loss. Yet it does not effect an equalization of work

between the two strokes. The full cylinder capacity is lifted on the upstroke nearly to the full height of the discharge, and on the downstroke but half of this is displaced from the height of the discharge opening, requiring little work on the downstroke. It is evidently a mistake to regard this device as an equalizer of work. The enlargement, to be fully effective, should continue down to the piston.

Compound pumps having four valves and discharging on both the upstroke and the downstroke, or two cylinder pumps in which one cylinder makes an upstroke during the downstroke of the other, would produce a resistance diagram such as shown in fig. 42. This diagram

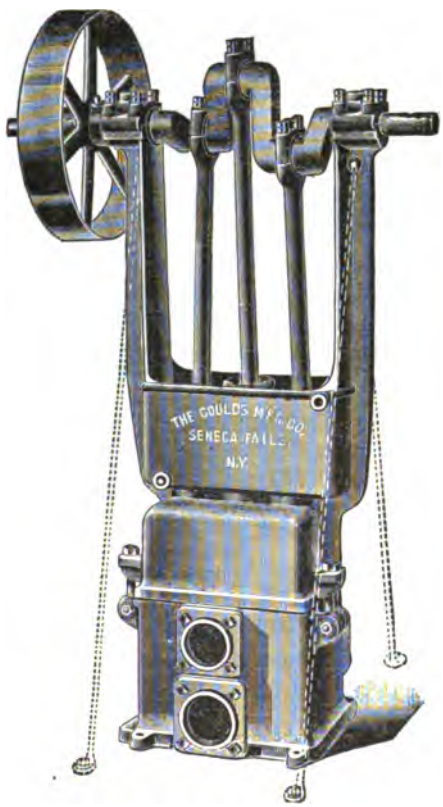


FIG. 44.—Gould triplex power pump.

represents the crank resistance of a pump discharging the same quantity of water per revolution of the crank as the pump represented in fig. 39 (p. 66). The curve below the zero line exhibits the effect of the weight of piston and rod, and the curve above the resistance due to lifting piston, rod, and water. The shaded portions show the resistances at each point in the revolution, the piston weights balancing each other. In this double-cylinder form the maximum resistance is about 1.6 times the average resistance, as against 3½ times with the

single-cylinder form. At two points in each rotation the resistance will be zero, but it does not fall below zero, as with the single-cylinder form. A pump of this kind can be more easily driven by horse power than one with a single cylinder, but it is, on the other hand,

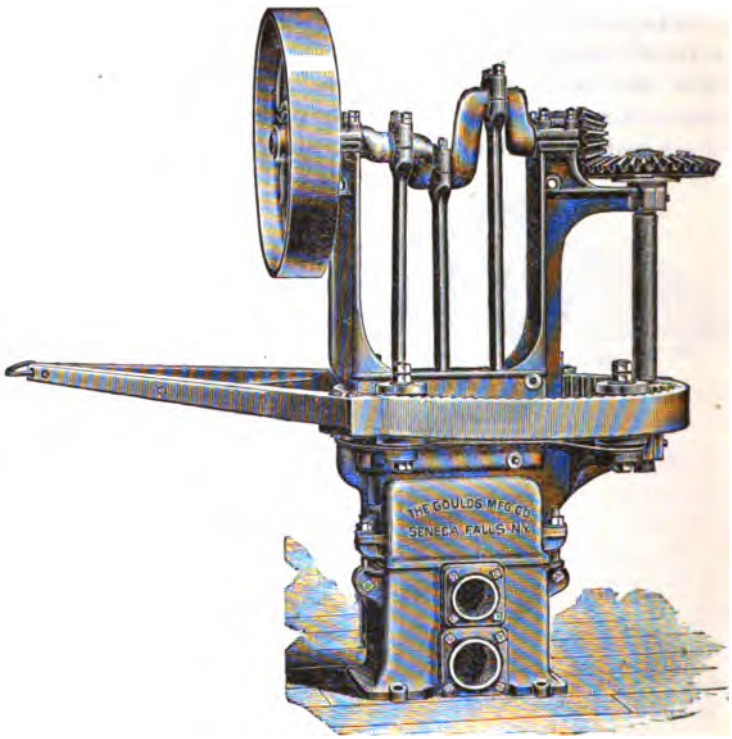


FIG. 45.—Gould triplex pump and horsepower combined.

too irregular in action to admit of any considerable speed. With a single large cylinder counterweighed as above described the resistances are as shown in fig. 42 (p. 68) and the efficiency is greater than with two small cylinders.

Fig. 43 (p. 68) shows the resistances in a three-cylinder pump arranged to discharge the same quantity per revolution as did the

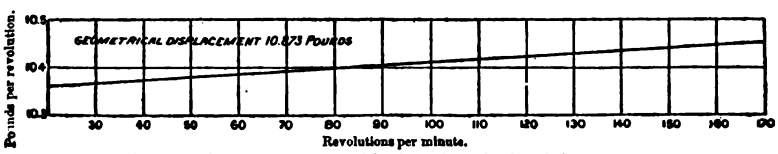


FIG. 46.—Discharge of Gould 4-inch by 8-inch triplex pump.

two-cylinder and the one-cylinder forms. The three pistons are driven from three crank elbows in the shaft set at 120° each to each, as shown in fig. 44 (p. 69). The resistance offered by this

device is very uniform, as appears from the shaded portion of the diagram. The maximum resistance is but 6 per cent above the average resistance, and a moderate fly wheel renders the motion entirely steady.

Such pumps admit of the best use of any constant power, as that of a horse or a small engine. In Gould's triplex pump (fig. 44), a horse will encounter a nearly uniform resistance and can work to the best advantage. A 4 by 8 inch pump of this make was tested by the

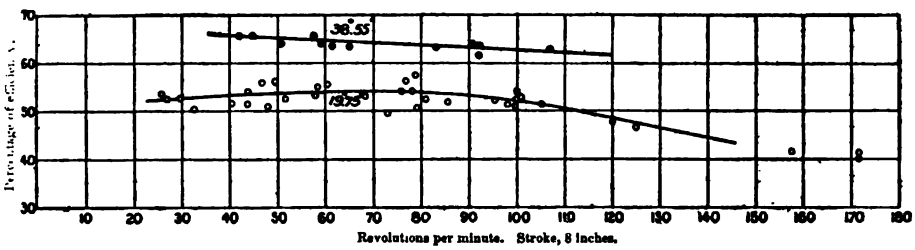


FIG. 47.—Varying-efficiency curves of Gould triplex pump, showing effect of varying speed, and at two different lifts.

author at three different lifts. The crank shaft is arranged to be run by a pulley belted from any source of power, or by means of the encircling internal master wheel and the vertical shaft carrying bevel gears, as in fig. 45, and operated by means of a horse attached to a sweep on the master wheel. The very uniform resistance of this kind of pump, as shown by the diagram, fig. 48, which represents the belt pull or resistance while at work, has opened a large field for it

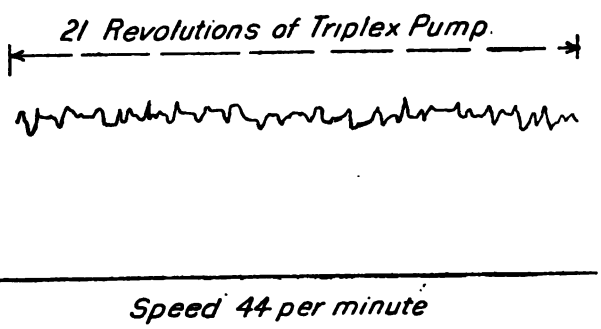


FIG. 48.—Dynamometer diagram showing uniformity of resistance afforded by triplex pump.

in connection with various motors. While not so efficient as a single-cylinder pump of equal capacity, yet it applies energy so effectively as to render it the more advantageous form for many uses. The efficiency of the one tested is seen to be about 60 per cent—not greater than that of many homemade water lifts. Its durability and compactness, however, entitle it to very favorable consideration in comparison with any such homemade device.

Discharges of Gould triplex pump.

LIFT, 19.75 FEET.

Speed, in revolutions per minute.	Discharge per minute by experiment.	Average discharge per minute by discharge curve.	Average discharge per revolution.	Speed, in revolutions per minute.	Discharge per minute by experiment.	Average discharge per minute by discharge curve.	Average discharge per revolution.
	Pounds.	*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*	*Pounds.*
30	331	308	10.2	75	784	783	10.4
30	321	308	10.2	79	816	825	10.4
36	353	373	10.3	82	876	857	10.4
47	476	490	10.4	90	947	941	10.4
52	539	542	10.4	99	1,035	1,035	10.4
56	581	583	10.4	111	1,175	1,161	10.4
57	644	595	10.4	114	1,208	1,192	10.4
60	628	625	10.4	114	1,213	1,192	10.4
65	672	678	10.4	133	1,390	1,390	10.4
70	728	730	10.4	156	1,630	1,631	10.4
74	771	772	10.4	166.8	1,720	1,745	10.4

LIFT, 38.55 FEET.

40	416	416	10.4	84	898	853	10.4
45	482	468	10.4	90	964	941	10.4
77	827	803	10.4				

Figures from efficiency test of Gould triplex pump 4 by 8 inches.

LIFT, 19.75 FEET.

Speed, in revolutions per minute.	Discharge per minute.	Foot-pounds of useful work per minute.	Foot-pounds of work given to pump per minute.	Mechanical efficiency.
	Pounds.			*Per cent.*
25.9	265	5,234	9,715	53.8
27	276	5,451	10,370	52.5
29.5	303	5,984	11,429	52.3
32.8	338	6,675	13,283	50.2
40.5	420	8,295	16,008	51.8
43.8	455	8,986	17,569	51.1
43.8	455	8,986	16,588	54.1
46.9	487	9,618	17,213	55.8
48	500	9,875	19,405	50.9
49.6	515	10,171	18,133	56.1
51.8	540	10,665	20,260	52.6
58.2	607	11,988	22,410	53.5
58.8	612	12,087	21,952	55
60.6	639	12,620	22,771	55.4
68.2	712	14,062	26,391	53.2
73.2	764	15,086	30,330	49.7
76	794	15,681	29,063	53.9
78.2	815	16,096	29,809	54
79.2	825	16,292	33,309	48.9
81.1	848	16,748	32,072	52.2
85.7	895	17,666	35,743	51.8
95.3	997	19,690	37,750	52.1
98.3	1,026	20,263	39,710	51
100	1,047	20,678	40,175	51.4
100	1,047	20,678	40,413	51.1
101	1,055	20,836	39,430	52.8
105.3	1,100	21,725	42,409	51.2
120	1,255	24,786	51,698	47.9
125	1,305	25,773	55,209	46.7
157.9	1,650	32,587	78,199	41.6
171.4	1,790	35,352	86,142	41
171.4	1,790	35,352	87,987	40.2

Figures from efficiency test of Gould triplex pump 4 by 8 inches—Continued.

LIFT, 38.55 FEET.

Speed, in revolutions per minute.	Discharge per minute.	Foot-pounds of useful work per minute.	Foot-pounds of work given to pump per minute.	Mechanical efficiency.
	Pounds.			*Per cent.*
42.1	439	16,923	25,801	65.6
44.8	465	17,925	27,167	65.9
50.8	530	20,431	31,765	64.3
57.7	600	23,130	35,144	65.8
59.4	618	23,824	37,177	64
61.2	640	24,672	39,027	63.2
65.2	675	26,022	41,058	63.3
83.3	870	33,538	52,978	63.3
90.9	950	36,622	57,212	64
92.3	965	37,201	58,517	63.5
92.3	965	37,201	60,085	61.9
107.1	1,120	43,176	69,324	62.2

VARIOUS WATER LIFTS.

On the Western plains devices for raising water other than the reciprocating pumps are not common. The centrifugal pump, which, if driven at a high and uniform speed, has an efficiency of about 66 per cent at a lift of about 16 feet, has its field limited to tracts where water is to be found at comparatively shallow depths and to applications where motive power giving uniform and high speed may be economically employed. It is not well adapted to horse or windmill power.

Early forms of water lifts are mentioned and illustrated by Weisbach. While these are of interest, they are not likely to be used by American farmers, who are impatient of slow and laborious methods. The following statements are abstracted from Mechanics of Pumping Machinery, by Weisbach and Hermann:

Men, bailing with buckets holding about one-third of a cubic foot each, can lift 15 buckets per minute, 3 to 4 feet high, for a length of time daily equivalent to six hours of steady labor. This amounts to about 390,000 foot-pounds per day, or a quantity of water sufficient to cover an acre one-half inch deep. With deeper wells the sweep or weighted lever will yield about the same result in foot-pounds daily per man. At a crank handle an ordinary laborer can exert a force of 15 pounds in steady work, or can labor steadily at a rate of approximately 3,300 foot-pounds per minute. This is about the best manner of employing human labor. From a 10-foot well a man with a winch and bucket, properly proportioned, can cover an acre with one-half inch of water in a day. Approximately the same can be done with a hand pump suitably proportioned to the lift. The Dutch scoop, which consists of a long-handled scoop shovel suspended from an overhead support by a rope and swung by three men, will lift water 3¼ feet and throw it 6½ feet horizontally. One man working thus alone can do

about as much work as by the bailing method, but three men working together on a single scoop will do more than five men bailing separately.

BUCKET LIFTS.

A very old device for raising water consists of a vertical rope or chain carrying buckets, the chain running on a power-driven sprocket wheel at the top and maintained in proper position by a loose sprocket suspended in its lower loop. The modern development of the sprocket wheel and of the cast-link belt, in which links may be had specially adapted to receive sheet-metal buckets, has brought the bucket lift

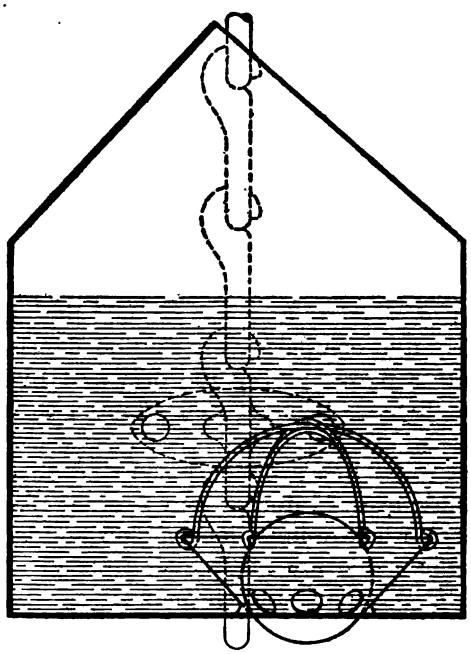


FIG. 49.—Vertical section of bucket of water elevator.

into renewed use. A modern form is shown in Pl. I, *A*. (See also fig. 49.) Its great advantages are uniformity of resistance and steady delivery. Its disadvantages are: large size for a given capacity, necessity imposed for using a large well, and difficulty in securing a perfect delivery. The buckets must be so made that in dipping into the water air will not be entrapped, and so that when delivering air may again readily enter. It has so far not been found practicable entirely to prevent loss from spilling of a portion of the water lifted. Furthermore, for emptying, the lift has to exceed somewhat the height of the discharge point. From these two inherent defects results a noticeable failure in efficiency.

SEAMAN BUCKET LIFT.

A lift designed for irrigation work, and made by Seaman & Schuske, of St. Joseph, Missouri, was tested, and the result appears

A—VIEW OF LINK-BELT WATER ELEVATOR.

B.—VIEW OF BOYCE WATER LIFT.

in fig. 50. This device consists of a series of galvanized-iron buckets, riveted to lugs carried on a common link belt. The sprocket chains, at each side of the bucket, are carried on two sprocket wheels. Each bucket is provided with a clay-ball valve, carried in a wire cage at the bottom of the bucket. The leather clack valve is a very old form for this use. With the rise of the bucket the valve—of whatever design—covers a circular aperture in the bucket bottom, and

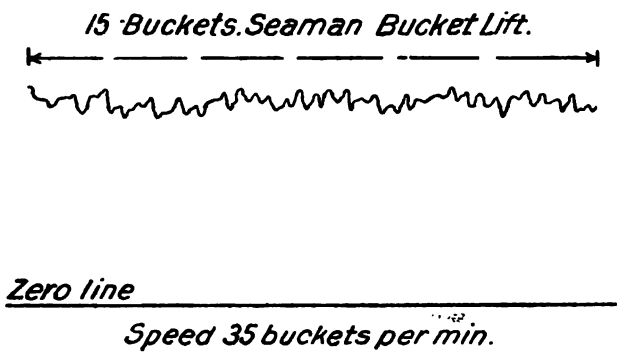


FIG. 50.—Dynamometer diagram showing uniformity of resistance afforded by Seaman bucket lift.

opens in turn with the descent into water, thus obviating the possibility of entrapping air. In the pendent loop of the chain two sprocket wheels on a shaft run without bearings. A gear on the main sprocket shaft is driven by a pinion, the power for which may be derived from any source.

The uniformity of the resistance offered by this lift is shown in fig. 50, taken from a recording dynamometer when the device was delivering about 300 pounds of water per minute, from a depth of 18.8 feet.

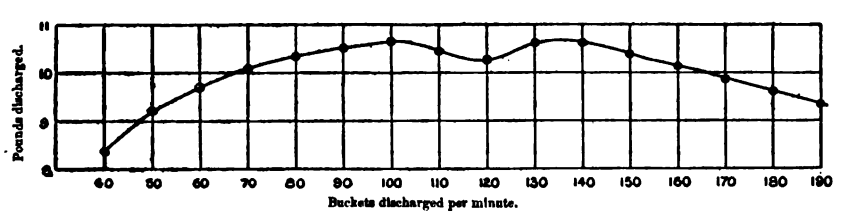


FIG. 51.—Discharge per bucket of Seaman bucket lift at various speeds.

Fig. 51 gives the discharge per bucket at various speeds, and fig. 52 the total discharge. The efficiency, as shown in fig. 53, is about 60 per cent at the favorable speed of 100 buckets per minute. A peculiar drop appears in the discharge record at speeds ranging from 100 to 130 buckets per minute. At very slow speed the discharge is less, due to leakage around the valve, and due, further, to failure of the buckets to empty into the discharge chute. At higher speed the valve loss becomes small, but the buckets soon pass the discharge

chute before fully emptying. At still higher speed centrifugal force aids greatly in discharging the bucket and temporarily increases the discharge. As speed still further increases, however, swaying of the chain causes loss, by slopping, from the rising buckets.

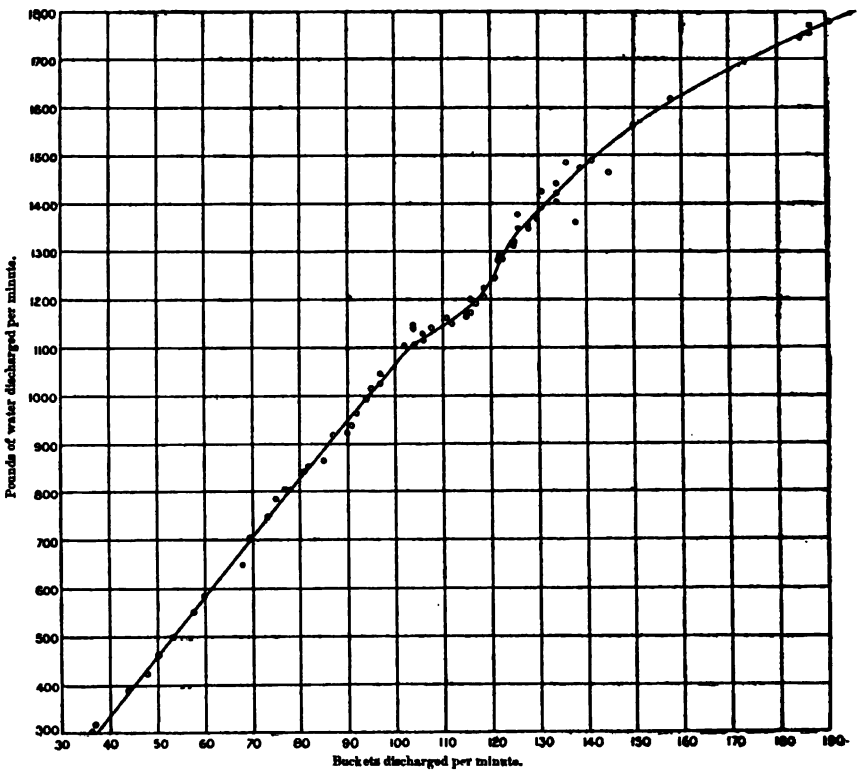


FIG. 52.—Total discharge of Seaman bucket lift at various speeds.

This pump has been successfully used in connection with a windmill. It can be recommended wherever a large open well is available, and where the depth to water is moderate, say from 20 to 35 feet. It

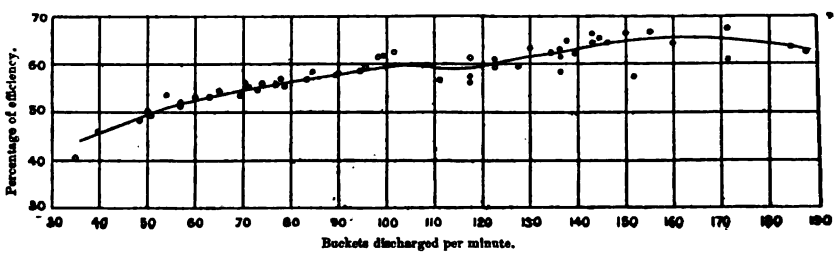


FIG. 53.—Efficiency curve of Seaman bucket at lift of 18.8 feet.

is best adapted to small powers of from 1 to 5 horsepower. The power necessary to operate such a pump is about double that represented by the useful work done, in water raised and discharged.

Discharges of Seaman bucket lift at various speeds.

Speed, in buckets per minute.	Discharge per minute by experiment.	Average discharge per minute by discharge curve.	Average discharge per bucket.	Speed, in buckets per minute.	Discharge per minute by experiment.	Average discharge per minute by discharge curve.	Average discharge per bucket.
	Pounds.	*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*	*Pounds.*
38	315	310	8.158	117	1,191	1,193	10.19
44	389	385	8.75	118	1,205	1,205	10.21
48	423	433	9.02	119	1,223	1,218	10.23
58	555	558	9.62	121	1,247	1,254	10.31
68	651	682	10.03	122	1,286	1,273	10.43
73	750	743	10.17	122	1,290	1,273	10.43
75	768	770	10.26	123	1,295	1,290	10.48
77	805	798	10.3	124	1,281	1,307	10.54
78	803	804	10.31	125	1,317	1,321	10.57
81	841	841	10.38	126	1,348	1,335	10.59
85	866	889	10.45	126	1,379	1,335	10.59
87	918	912	10.48	128	1,358	1,360	10.62
90	923	948	10.53	128	1,351	1,360	10.62
91	937	960	10.55	130	1,380	1,382	10.63
92	963	972	10.56	130	1,367	1,382	10.63
94	974	996	10.59	131	1,427	1,395	10.64
94	993	996	10.59	133	1,412	1,415	10.64
95	1,114	1,008	10.61	134	1,404	1,426	10.64
97	1,025	1,032	10.63	134	1,420	1,426	10.64
97	1,044	1,032	10.63	134	1,442	1,426	10.64
98	1,014	1,044	10.65	136	1,437	1,447	10.64
99	1,094	1,056	10.66	138	1,362	1,465	10.61
99	1,024	1,056	10.66	139	1,477	1,475	10.61
102	1,108	1,092	10.70	141	1,490	1,492	10.58
104	1,107	1,114	10.71	144	1,534	1,513	10.5
104	1,146	1,114	10.71	145	1,461	1,520	10.48
106	1,123	1,127	10.63	149	1,559	1,548	10.4
106	1,127	1,127	10.63	150	1,561	1,556	10.37
106	1,114	1,127	10.63	158	1,618	1,610	10.12
108	1,140	1,138	10.53	178	1,685	1,718	9.65
111	1,149	1,151	10.37	185	1,745	1,750	9.46
111	1,161	1,151	10.37	186	1,752	1,755	9.42
112	1,151	1,155	10.31	186	1,697	1,755	9.42
115	1,170	1,175	10.22	186	1,720	1,755	9.42
115	1,175	1,175	10.22	187	1,757	1,758	9.4
116	1,200	1,185	10.21	187	1,752	1,758	9.4
116	1,175	1,185	10.21	191	1,779	1,779	9.31

Figures from efficiency tests of Seaman bucket lift.

USEFUL LIFT, 18.8 FEET.

Speed, in buckets per minute.	Discharge per minute.	Foot-pounds of useful work per minute.	Foot-pounds of work given to machine per minute.	Mechanical efficiency.	Lift.
	Pounds.			*Per cent.*	*Feet.*
35.3	275	5,170	12,675	40.8	18.8
39.7	330	6,270	13,564	46.2	19
48.4	440	8,272	17,008	48.6	18.8
50	460	8,648	17,245	50.1	18.8
50.4	465	8,835	17,883	49.4	19
54	508	9,652	17,931	53.8	19
57.1	547	10,393	20,257	51.3	19
57.1	547	10,393	20,025	51.9	19
60	584	11,116	20,921	53.1	19
63.1	621	11,799	22,132	53.3	19
65.2	648	12,312	22,488	54.7	19
69.7	705	13,395	25,218	53.1	19
70.6	713	13,547	24,143	56.1	19
71.4	724	13,756	24,859	55.3	19
73	743	14,117	25,825	54.6	19
74	757	14,383	25,644	56	19
77	794	15,086	27,388	55	19
77.9	804	15,115	26,422	57.2	18.8
78.9	815	15,322	27,563	55.6	18.8
83.3	870	16,356	28,740	56.9	18.8
84.5	884	16,619	28,319	58.6	18.8

Figures from efficiency tests of Seaman bucket lift—Continued.

USEFUL LIFT, 18.8 FEET—Continued.

Speed, in buckets per minute.	Discharge per minute.	Foot-pounds of useful work per minute.	Foot-pounds of work given to machine per minute.	Mechanical efficiency.	Lift.
	Pounds.			*Per cent.*	*Feet.*
89.5	942	17,898	30,937	57.8	19
90	948	17,822	30,721	58	18.8
94.4	1,000	18,800	32,235	58.3	18.8
95.9	1,020	19,176	32,415	59.1	18.8
98.3	1,048	19,912	32,124	61.9	19
98.3	1,048	19,702	32,014	61.5	18.8
100	1,068	20,078	33,674	59.6	18.8
101.7	1,090	20,492	32,620	62.8	18.8
107.1	1,133	21,300	35,529	59.9	18.8
111.1	1,152	21,657	38,076	56.8	18.8
117.6	1,200	22,800	37,226	61.2	19
117.6	1,200	22,560	40,160	56.1	18.8
117.6	1,200	22,560	39,211	57.5	18.8
122.5	1,284	24,139	40,623	59.4	18.8
122.5	1,284	24,139	39,453	61.1	18.8
127.6	1,355	25,474	42,633	59.7	18.8
130	1,382	26,258	41,502	63.2	19
134.8	1,435	26,978	43,386	62.1	18.8
136	1,448	27,512	43,607	63	19
136.4	1,450	27,260	46,750	58.3	18.8
136.4	1,450	27,260	44,405	61.3	18.8
137.9	1,463	27,797	42,816	64.9	19
139.5	1,480	27,824	44,809	62.1	18.8
143	1,505	28,595	43,584	65.6	19
143	1,505	28,595	44,442	64.3	19
144.6	1,516	28,804	44,198	65.1	19
146.3	1,530	29,070	45,058	64.5	19
150	1,556	29,564	44,541	66.3	19
151.9	1,570	29,830	52,101	57.2	19
154	1,584	30,096	45,002	66.8	19
160	1,622	30,818	48,075	64.1	19
171.4	1,685	32,015	47,628	67.2	19
171.4	1,685	32,015	47,496	67.5	19
171.5	1,687	31,715	52,199	60.7	18.8
184.6	1,748	33,212	51,996	63.8	19
187.5	1,760	33,440	53,387	62.7	19

SAME USING TWO VALVES IN EACH BUCKET.

96	1,032	19,401	35,447	54.7	18.8
100	1,069	20,204	36,738	55	18.9
100	1,069	20,078	36,604	54.8	18.8
102.5	1,098	20,642	37,205	55.4	18.8
103.4	1,108	20,941	37,109	56.4	18.9
111.1	1,152	21,657	39,361	55	18.8
115.4	1,178	22,190	40,960	54.1	18.8
122.5	1,283	24,120	42,151	57.2	18.8
125	1,323	24,872	42,830	58	18.8
130.4	1,383	26,138	44,068	59.3	18.9
133.3	1,420	26,838	45,895	58.4	18.9
142.8	1,505	28,294	50,222	56.3	18.8
142.8	1,505	28,294	50,770	55.7	18.8
142.8	1,505	28,444	48,856	58.1	18.9
151.9	1,570	29,516	50,724	58.2	18.8
162.1	1,634	30,719	54,713	56.1	18.8
160	1,673	31,452	54,839	57.2	18.8
184.6	1,749	32,881	62,924	52.2	18.8
187.5	1,760	33,068	63,337	52.2	18.8

LIFTING BY ANIMAL POWER.

It is somewhat surprising that horses are not more used for lifting water. In small operations, or where a farmer is experimenting with a view to irrigation, horse power would seem to be the resource readiest to hand. It is but little recognized how much work may be got

from a horse if a suitable device be provided. Farm horses, like their masters, work especially hard during special seasons. Their rate is higher then than it could be if they were worked continuously. If the following estimates at first sight appear low, it should be understood that they are made on the assumption of a uniform daily rate. It is assumed that a good work team of two horses will pull 300 pounds steadily during a day of eight hours. In plowing, this effort is frequently doubled. For horses worked continuously at a straight-away pull, 125 pounds each for medium-weight horses is good average work. For occasional short periods a horse can throw one-third of his weight into his effort, but he can not do so at frequently recurring intervals. The maximum load for a horse, if recurring at short intervals, should not exceed double the average fair load, and the more frequently it recurs the less it should be. The natural gait of a work horse is about 3 feet per second. If loaded to pull 125 pounds at this gait, his work would be equivalent to 22,500 foot-pounds per minute, or about two-thirds of a horsepower.

If a horse could be worked steadily at some device the efficiency of which would be 66 per cent, he could lift, in a ten-hour day, $\frac{3.3}{L}$ acre-feet of water, L being the height of lift in feet. In many cases the lift will be about 15 feet, giving an output per horse of 0.22 acre-foot, and if the depth of irrigation be 3 inches, accompanied with the usual waste, the water for about three-fourths of an acre per day could easily be supplied by two horses. With storage and with intervals of ten days between irrigations a team of two horses could care for from 5 to 7 acres. While to the enthusiast these figures will not appear large, they are large enough to justify the use of horses in small undertakings. The assumed efficiency of 66 per cent is, in fact, low rather than high, and a device for the utilization of horsepower that shall attain to this percentage ought to be possible of achievement by mechanical skill.

The foregoing is a statement of what it is possible to do with horses if suitable machinery be provided; but the majority of existing devices will not do so well as this. As shown by the stress diagram for a single-cylinder pump (fig. 39, p. 66), the maximum stress is more than three and one-half times what would be the average stress. As the maximum effort of a horse should not rise to more than double his average effort, and as the average resistance in the single-cylinder pump is 28 per cent of the maximum resistance, the actual average load put on the horse can equal only 28 per cent of twice his average effort, or 56 per cent of his possible average effort. In order to get full work out of a horse, therefore, it would be necessary, at some period of each pump stroke, for him to make an effort more than three and one-half times his most efficient average effort. This would be too great irregularity of exertion.

A horse can not do full work on an unbalanced single-cylinder pump. It is imperative that recourse be had to some device which will more nearly equalize his efforts. The use of a sweep, by reason of the circular course a horse has to follow, involves a loss of 20 per cent of efficiency, as compared with the possible efficiency in a straight-away pull. At each point of his actual course he will be pulling at an angle with his most effective course, which at any point will always be a tangent to the circular path. Tests of the usual sweep horse-power show an efficiency of about 80 per cent.

A horse can deliver to a pumping device, through the medium of a sweep, 80 per cent of 80 per cent, or 64 per cent of his best effort. If the pumping device have an efficiency of 60 per cent, such as shown by the bucket lift, the water actually lifted will represent 80 × 80 × 60 per cent, or 38.4 per cent straight-away average effort of the horse. In the operation of a bucket lift of this kind,

$$\frac{8640}{L} = p,$$

in which L is the total lift of water in feet, and p the number of pounds discharged per minute for each horse employed.

To determine the proper speed for the bucket lift, let S be the length of sweep in feet, L the lift of water in feet, l b d the dimensions, respectively, of the buckets used in inches, and n the number of buckets emptied during one revolution of the sweep; then, for each horse

$$\frac{10{,}400\,S}{L\,l\,b\,d} = n.$$

Omitting from consideration what might be done by overtaxing the horse, a larger output than this is to be looked for only through increase of efficiency in the mechanism of either the sweep or the pump. This low efficiency, in which but 38 per cent of the power expended by the horse appears as returned in useful work, lies at the root of the nonuse of horsepower for these light water-lifting operations. As already stated, the difficulty does not to the writer appear insuperable.

SOME INDIAN DEVICES.

Among devices employed in India for raising water from wells by animal power a number have been tested as to their mechanical efficiencies, and have been reported upon to the Madras government in Bulletin No. 32 of the department of land records and agriculture, under the title, Experiments with Water Lifts. The following copious extracts from this interesting report, together with figs. 54, 55, and 56, which are selected reproductions from its plates, show what may be accomplished with these rude devices of the Indian farmer, to whom the cost of modern machinery is, as a rule, prohibitive.

The experiments conducted by the committee had the following objects in view: The determination of—

(1) The quantity of water and the effective height it was lifted in a given time by bullocks of known weight, and working in a way that did not unduly fatigue them.

(2) The quantity of work actually obtained from the animals in the same time.

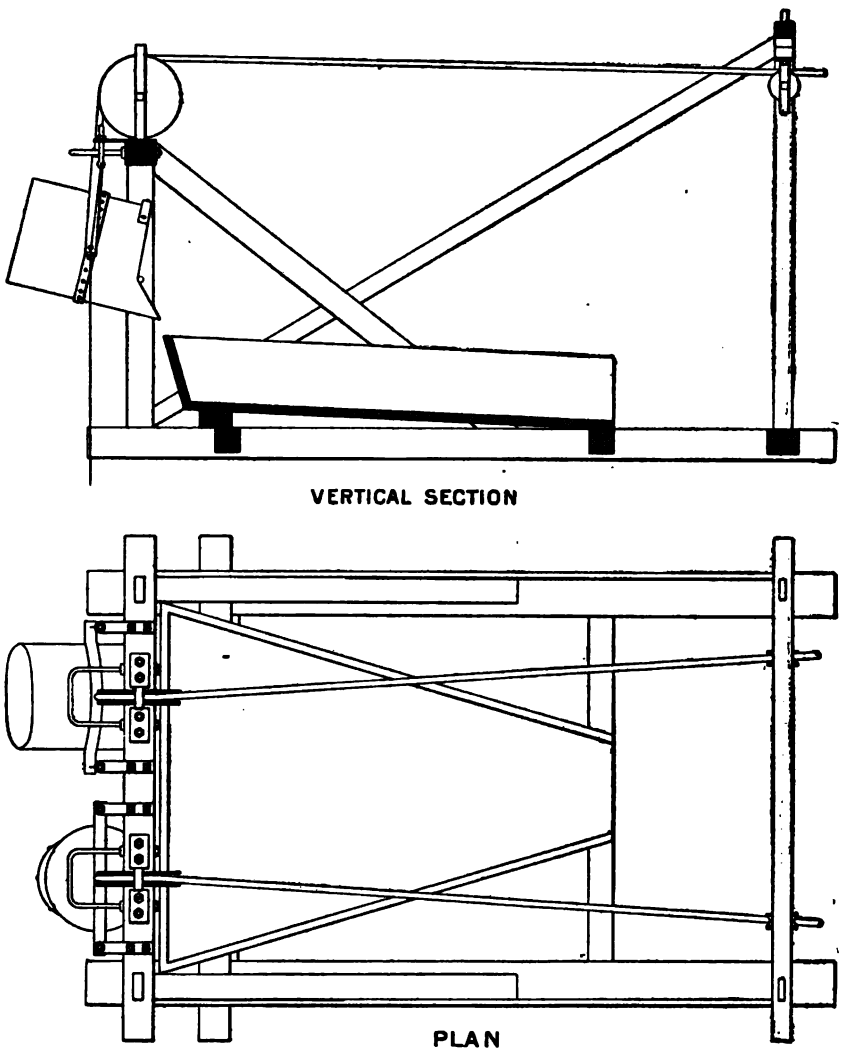


FIG. 54.—Plan and vertical section of Stoney water lift.

(3) The quantity of work which might have been obtained from the animals in the same time had the working of the lifts been continuous.

The first quantity divided by the second gives the mechanical efficiency of the water lift, and the first quantity divided by the third gives its absolute efficiency as a machine for utilizing animal power in a given way.

(4) The quantity of work represented in water lifted per hour divided by the weight of the bullocks in pounds.

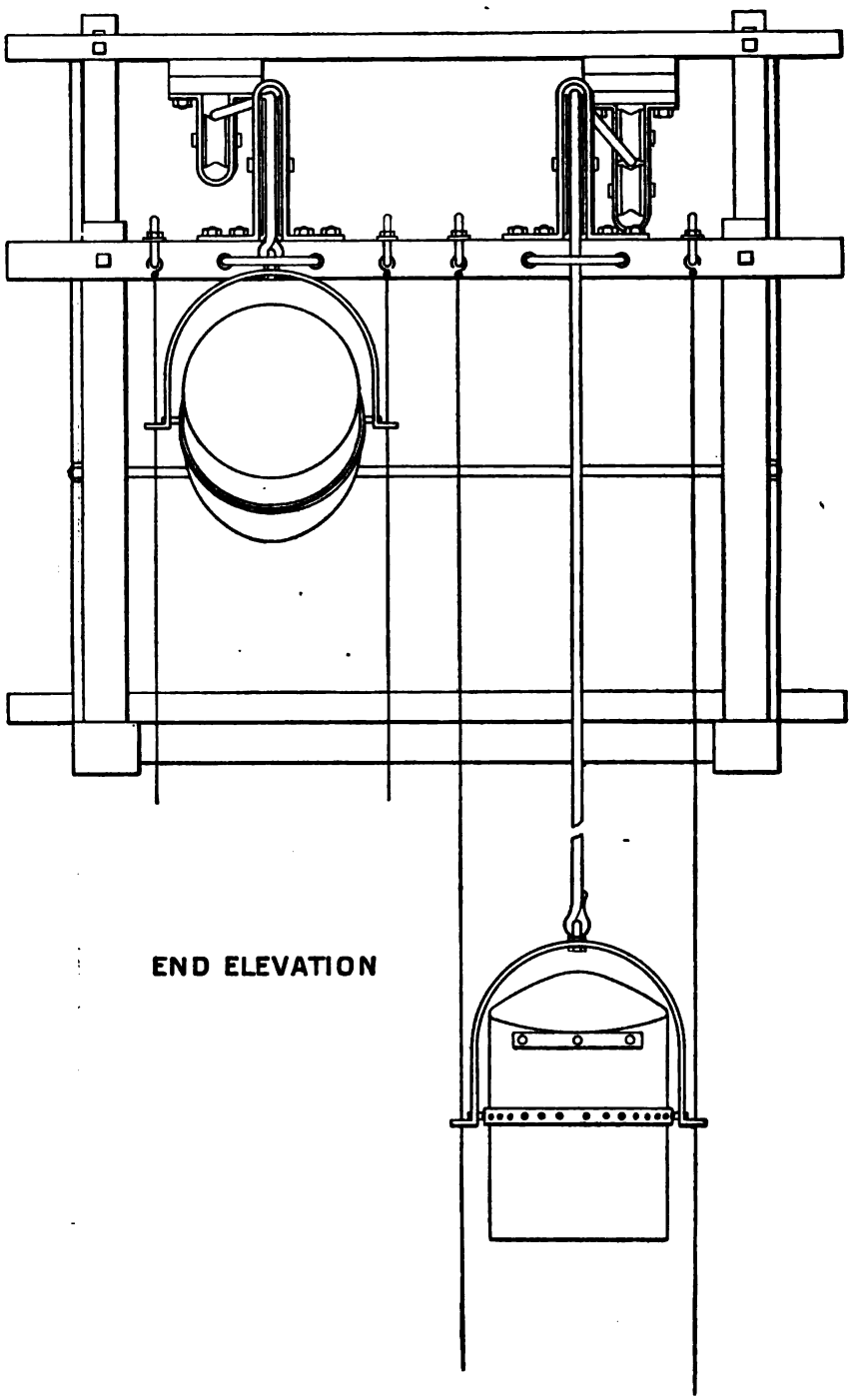


FIG. 55.—End elevation of Stoney water lift.

This yields a constant which, on the assumption that the animals employed in working the various lifts are all equally strained, enables a comparison to be made between very different types of water lift and very different methods of applying animal power. In some lifts only the draft of the animals is utilized. In others, as for instance the ordinary single mhote, both draft and weight are utilized, whilst in a third class only the animals' weight is made use of, as in Mr. Subba Rao's oscillating platform; and between such very different methods the constants yielded by (4) seems to be the best method of making comparisons of the actual value of different machines for lifting water. It must be remembered

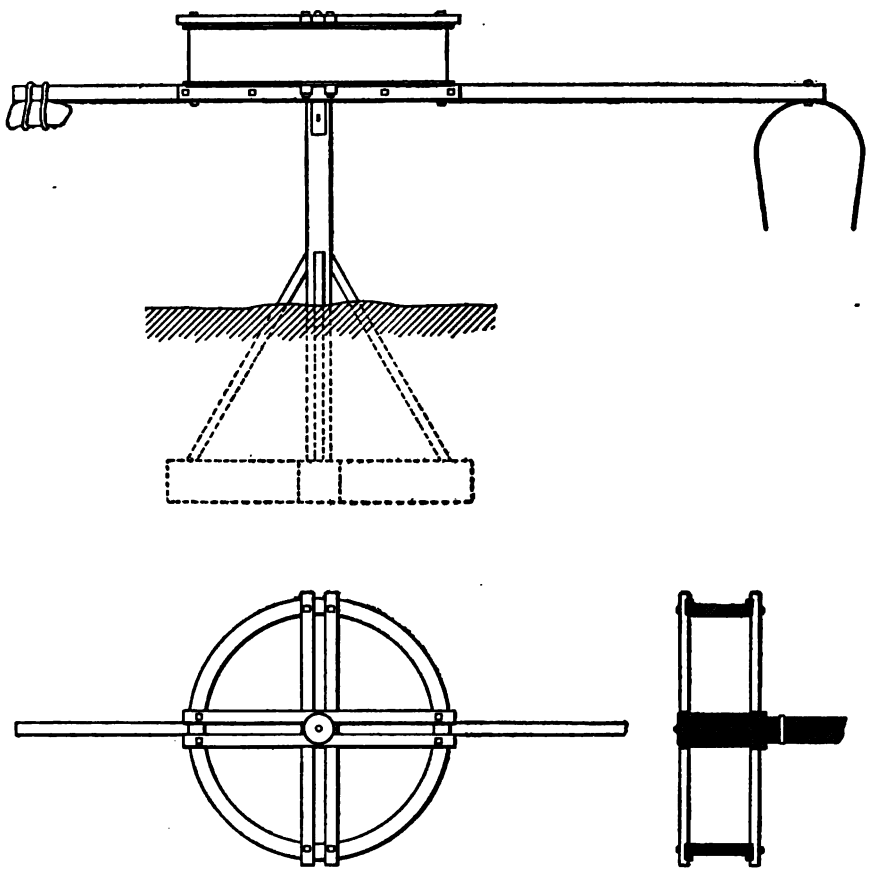


FIG. 56.—Whim used with Stoney water lift.

that though the mechanical efficiency of a water lift may be high, yet the mode of getting the work out of the animals employed may be bad, and the actual value of the constants yielded by (4) depends on the assumption that the strength of animals is proportional to their weight, which is probably roughly true for animals in good working condition and in the prime of life, and on the accuracy with which it is possible to estimate whether two animals working in different ways are exerting themselves to their full working capacity. The figures therefore obtained are only to be taken as offering a rough method of comparing the different lifts, and as a guide in estimating their probable value as machines for lifting water.

Stoney's water lift.—The principal feature in this lift is the employment of buckets of wrought iron, suspended in a stirrup by two adjustable pivots attached to the bucket very slightly above the center of gravity of the bucket when full of water. The mouth of the bucket is inclined as shown in the drawing, and the lower ends of the stirrup are turned outward and encircle steel wires which are suspended in the well from screw eyebolts attached to the framing above. The wires are fastened by some convenient means to the bottom of the well and act as guides to the bucket, ascending and descending, and prevent it from either turning round or swaying to and fro, and thus striking either the sides of the well or the second bucket. On the bucket being lowered into the water it turns horizontally and rapidly fills with water, and on being drawn up assumes a vertical position and rises steadily out of the water, till the discharging level is reached, when the upper side of the inclined mouth comes into contact with an iron bar fixed across the framing of the lift, and the stirrup, continuing its upward motion, causes the bucket to revolve about the point of contact of the bucket with the iron rod, and thus discharge its contents into the delivery trough. The lift was worked by carrying the ropes which hold the buckets over guide pulleys to a whim turned by either a pair of bullocks or a single bullock. Two buckets were attached and the ropes arranged so that as one bucket ascended the other descended, and the dead weight of the buckets was balanced. The whim consisted of a drum built of wood and carried by an iron spindle on the top of a post firmly built into the ground. The bullocks worked at the end of a long arm, the circumference swept out by which was 3.85 times the circumference of the drum. The whim is worked alternately in one direction and the other, the cattle being made to turn round while the bucket is discharging its contents. The lift was provided with two sets of buckets of a nominal capacity of 30 and 25 gallons (English), respectively. In the following table is exhibited the data regarding their capacity:

TABLE I.

		Weight, empty.	Weight of water when full.	Weight of water delivered by buckets.
		Pounds.	*Pounds.*	*Pounds.*
30-gallon buckets	No. 1	101	296	280
	No. 2	98	295	280
25-gallon buckets	No. 1	68	245	230
	No. 2	67	237	230

The capacity of the lift was tested by working it with a single Nellore bullock weighing 1,146 pounds on three different days, but owing to insufficiency of water in the well no test could be continued for more than two hours forty-two minutes. In Table II the results obtained are shown:

TABLE II.

Date.	Time started.	Time stopped.	Number of buckets raised.	Lift at beginning.	Lift at end.	Mean lift.	Gallons raised per hour.	Foot-pounds of useful work done.
				Ft. in.	*Ft. in.*			
July 16, 1895	8-37	9-37	*a* 88	22 0	.....	22.625	2,594	586,900
	9-37	10-07	*a* 51	.....	23 8	.....	.....	.....
	2-04	3-04	*a* 91	21 10½	.....	.....	.....	.....
	3-04	4-04	*a* 86	.....	.....	23.24	2,489	575,500
	4-04	4-46	*a* 63	.....	.....	.....	.....	.....
July 17, 1895	2-00	3-00	*a* 85	22 2	.....	22.87	2,391	546,900
	3-00	3-51	*a* 73	.....	23 6½	.....	.....	.....
July 18, 1895	2-29	4-29	*b* 167	22 2	.....	22.75	1,886	429,000
	4-29	5-29	*b* 79	.....	23 4	.....	.....	.....

a 30-gallon buckets. *b* 25-gallon buckets.

The mechanical efficiency of the lift when just moving is 83.6 per cent, and at the ordinary working speed, 79 per cent. It was found that the speed at which the bullock walked when exerting a draft of 92 pounds was, as the mean of a number of observations, 3.64 feet per second, and that in 162 minutes he raised 240 buckets of water, lifting each bucket 23 feet. Walking at this speed without stopping, which without doubt the animal could have easily done, he could have lifted 401 buckets, so that he was only usefully employed for 59.7 per cent of the time. The absolute efficiency of the lift was therefore 79 by 59.7 per cent or 47.2 per cent. This calculation neglects to take into account the extra pull which is necessary to tilt the bucket to make it discharge, which was found to amount to 122 pounds and which was exerted through about 3 feet. This quantity would only affect the result very slightly and the decrease in efficiency would diminish as the height to which the water has to be raised increases.

A device of this kind is among the possibilities of home manufacture in any American community. The results given were obtained from actual trial and could be duplicated here by the use of horses.

A device called an improved single mhote was also tested and described. A water carrier holding 31 gallons was provided, at its bottom opening, with a large leather pipe. This carrier or bucket was suspended by a rope from a pulley, and the free end of the leather discharge pipe was separately suspended and held up by a second rope passing over a pulley below the bucket pulley at the ground surface. The discharge end of the leather pipe was ordinarily held above the bucket, and in this position permitted no discharge. Upon the ascent of the bucket and its upturned discharge pipe or leather tube the tube would be drawn out along the ground by its controlling rope and discharge effected as soon as the bucket passed above the ground surface. The two ropes were connected in such manner that they were operated together, the pull being exerted by bullocks descending an inclined plane which had been excavated below the ground level.

The improvement on the ordinary single mhote is effected by attaching a rope to the draft rope and carrying it on to the large drum of a kind of windlass erected at the end of the inclined plane and at a considerable height above the level of the end of the run. Cords wound round two smaller drums, one on each side of the large drum, carry weights, which it was found almost balanced the weight of the empty bucket, so that at the end of a lift, as soon as the bucket was empty, the draft rope automatically rose in the air and the bullocks were able to turn round and walk up the inclined plane in a natural, easy manner instead of being forced backward, as is the common plan. The improvement effected is undoubtedly a very great one, as not only is the weight of the empty bucket practically balanced, but the animals are also spared the cramped and unnatural backward walk up a steep incline, which probably tires them more than their exertions in drawing the bucket out of the well. The experiments made on this lift were not very extensive, but the following results were obtained and are worthy of record. The mhote was worked by two bullocks weighing 732 pounds and 616 pounds, respectively, or in the aggregate 1,348 pounds. The bucket, which was of iron and fitted with a leathern discharge trunk, weighed 43 pounds and when full held 31 gallons of water, but the mean quantity lifted, as measured into a tank, was 24.2 gallons per lift, the rest being spilt or lost by leakage. With the bullocks employed the rate of working was 90 lifts per hour, and the height of the lift being 23 feet, the total quantity of work usefully done amounted to 500,940

foot-pounds per hour. The draft exerted by the bullocks down the inclined plane was found to be 383 pounds. The useful work done in a single lift was 24 × 10 × 23 or 5,570 foot-pounds, whilst the bullocks exerted a pull of 383 pounds through 25½ feet, the bucket having to be raised an extra 2½ feet to enable it to discharge its contents, and the work done is equal to 9,760 foot-pounds. The bullocks then had to return up a gradient of 1 in 5.28 feet, in doing which they expended 6,510 foot-pounds of energy in lifting their own weight against the action of gravity. The total amount of work done by them in a single lift was, therefore, 16,570 foot-pounds and the useful outturn 5,570 foot-pounds, so that the efficiency of this method of lifting water is not greater than 34.3 per cent. As compared with the ordinary single mhote, the great advantage which this lift possesses is that it allows the bullocks to turn round at the bottom of the inclined plane and ascend walking forward instead of backward, an advantage which it would be difficult to express numerically, but the balancing of the bucket diminishes the draft by about 40 pounds and increases the efficiency of the lift by about 6.3 per cent, not, perhaps, a very large amount, but still by no means a negligible quantity.

A see-saw lift described is unique, and might be developed into a practical device:

In this form of water lift the bullock is made to walk along a platform supported on a roller, and by his weight it is caused to oscillate up and down. Two ropes are attached to one end of the platform and wound round two small drums forming part of a windlass, round the large drum of which a rope working an ordinary single mhote is passed. The platform is not supported in the middle, but at some distance therefrom, so that the working end of the platform greatly preponderates and the bullock has to walk to the free end of the platform to tilt the longer segment up and lower the bucket into the well. The platform is 24 feet long and the supporting roller is fixed 15 feet 3¾ inches from the working end. It was not possible to weigh the platform, and calculations of its weight, based upon the quantity of timber used in it, can only be approximate. It was, however, carefully measured up, and assuming that the teak wood, of which it was constructed, weighed 45 pounds per cubic foot, the weights of the two sections are 1,450 pounds and 850 pounds. To diminish the shock when the free end falls and the bucket is lowered into the water, 230 pounds of iron rails are fastened underneath the platform by a short chain, so that just before this end of the platform reaches its lowest position the rails rest on the ground and their weight ceases to act, and the platform comes to rest more gently than would be the case if the velocity of descent continued to accelerate to the very end. The ropes from the platform were wound round drums, the circumference of which was 3 feet 2¼ inches as measured by unwinding one coil of the rope, and the mhote rope was worked from a drum 7 feet 10 inches in circumference so that the motion of the working end of the platform was multiplied 2.44 times. With the bucket empty and the platform horizontal the load at the free end could be varied from 160 pounds to 362 pounds without disturbing the equilibrium, whilst with a load of 247 pounds in the bucket, equal to 24.7 gallons of water, the platform remained horizontal, though the load at the working end varied between 584 pounds and 275 pounds. Taking the mean between the two extreme values to be the actual weight required to balance the platform, it is possible by taking moments about the center to determine the only force acting on the platform which was not measured, viz, the weight of the empty bucket and ropes acting with a lineage of 2.44 to 1. With the bucket unloaded, the weight works out as 65.4 pounds and when loaded 62 pounds, a remarkably close agreement.

The lift was worked during the trial by a bullock weighing 700 pounds and a man weighing 117 pounds. The rate of working was 81 lifts per hour from a well 18 feet 1 inch deep. The average quantity of water brought up by the bucket, as measured into a tank, was 23.5 gallons, and the useful work done per hour

amounted to 344,210 foot-pounds. The bullock and the man together were much heavier than was really necessary, and they did not use the full length of the platform, so that it is difficult to estimate the work done by them in working the lift, but the mechanical efficiency of the lift on the day of trial can be ascertained by multiplying the fall of the front end of the platform by the force required to set it in steady motion when lifting a bucket full of water. The total height the bucket had to rise to discharge its contents was 22 feet, and the end of the platform therefore fell 9 feet and the work done was 584 × 9 = 5,256 foot-pounds. To raise the platform back to its initial position the free end then falls 5.18 feet and the load on it is 362 pounds, and the work done is equal to 1,875 foot-pounds. The total work, therefore, done in a single lift is 7,131 foot-pounds, and the useful work given to the water is 4,245 foot-pounds, so that the mechanical efficiency, when just working, is 59.6 per cent; at the normal rate of working it is much lower, probably not more than 50 per cent.

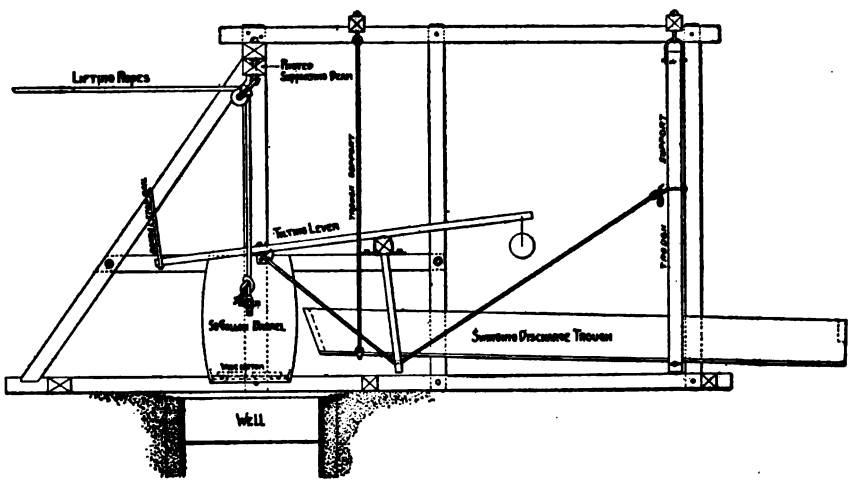


FIG. 57.—Construction of Boyce water lift.

The conclusion reached by the engineer, Mr. A. Chatterton, who made the tests, was that "the most efficient way of utilizing animal power is to make the animal raise himself against the action of gravity, and then, in some way, convert the potential energy stored in the animal's body into work."

AN AMERICAN DEVICE.

An American water lift, devised by Mr. A. Boyce, of Augusta, Oklahoma, was exhibited at Garden, Kansas, in 1896. Figs. 57, 58, and Pl. I, *B* (p. 74), show its construction and general mode of operation. Its very considerable merit lies in the readiness with which it may be constructed on the farm, and in its cheapness. The general plan of the device may be described as follows:

The running gear of an ordinary farm wagon, with the two wheels of one side removed, has its axles fixed radially to a circular track, the diameter of which is made to exceed slightly the total height of the water lift. The axles are bolted to beams which extend to the center of the circular track, where they are pivoted to a low post.

Horses hitched in the usual manner draw this two-wheeled device around the circle. A vertical post, rigidly braced on the wagon frame and extending to a height somewhat above the backs of the horses, carries at its upper end a vertical pin, to which ropes are attached by means of a loose link and extended to a lifting device at the well. As the wagon travels around the track, the framework, as a whole, acts as a crank, the throw of which is equal to the height of lift of the water. The ropes extend horizontally from the top of the traveling post to the well framework, so that the horses pass beneath them. By simple multiplication of ropes more than one well may be drawn upon. Where, however, there is but a single well, a counterbalance upon the wagon must be used to prevent overturning. In the well is a bucket, hung at either side on gimbals, attached a little above its center of gravity when full, so as barely to insure stability. In the bottom of the bucket two large clack valves admit of the ingress of water. The supporting ropes, one on each side, pass through pulley blocks over head and thence horizontally to the crank link on the wagon post. These pulley blocks hang from the ends of a short beam, pivoted at its center so that it may always maintain a position normal to the continually changing direction of the ropes.

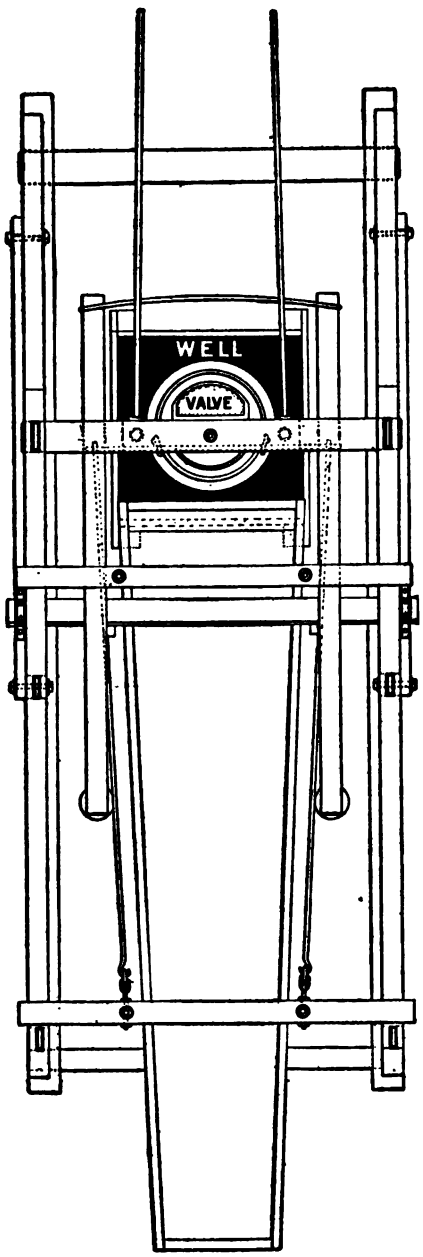


FIG. 58.—Construction of Boyce water lift.

The mechanism for emptying the bucket is designed to receive its full discharge and at the same time to avoid shock. A swinging trough is suspended at four points, by rods, from the framework overhead. As the bucket reaches the summit of its rise it encounters a cross rod, on a tilting lever, as shown

in fig. 58. The tilting of this lever draws forward the trough supports by means of an adjustable connecting rod and swings one end of the trough under the tilting bucket. The bucket is prevented from tilting too far by a bail on the tilting lever.

This device is simple and very direct in operation. If applied to a single well, it has the fault of being single-acting, and horses can not be worked to their full capacity without overstrain. The resistances for one revolution would be, practically, as shown in the diagram, fig. 39 (p. 66). To render this work more nearly uniform three or more wells should be drawn upon at the same time. Three wells placed at the points of an equilateral triangle, with the sweep operating at its center, could be served nearly as easily as one. The mechanism is so direct acting that an efficiency of at least 80 per cent could be expected, as with the similar device of Mr. Stoney.

In the case of a single well the full weight of the loaded bucket will come upon the horses at that moment when their direction of pull falls in line with the rope. If a team of two horses can pull 400 pounds for a short distance, the weight of bucket and water may be 80 per cent of that amount. A 50-gallon oil barrel makes a good bucket. The barrel will weigh, when wet, about 70 pounds, and when three-fifths full will have the weight given above.

If three wells be used the resistance will be so uniform that an average pull of 200 pounds, for two horses working in a circle, may be taken as a basis for determining the proper dimensions for the buckets. If the machine has frictional resistances of but 20 per cent the water in each bucket may weigh 160 pounds, and in one revolution 480 pounds, or about 57 gallons, can be discharged. The number of revolutions per minute will depend upon the size of the circle described by the horses, and will be $\frac{57}{L}$ if the diameter of the circle is made equal to the height of the lift. The gallons discharged per minute will be $\frac{3313}{L}$, and the acre-feet, per day of ten hours, $\frac{6.1}{L}$. A mechanical advantage may be secured by attaching the crank post to the sweep at a point nearer to the center than the point to which the horses are attached. It will thus describe a smaller circle. In consequence larger buckets may be used.

This device is adaptable to any number of horses and to any number of wells. Mr. Boyce makes the statement that, "using two buckets drawing from one well, one bucket ascending as the other descends, I can raise 200 gallons per minute from a well 27 feet deep, with a small team of [two] horses." While this is heavy work for two horses, and probably could not be maintained continuously for ten hours, it shows what could be done on occasion. No accurate tests of efficiency have been made, so far as I know.

A device of this kind is well worth the attention of beginners in irrigation who wish to avoid a large initial outlay for machinery.

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1895.

Sixteenth Annual Report of the United States Geological Survey, 1894–95, Part II, Papers of an economic character, 1895; octavo, 598 pp.

Contains a paper on the public lands and their water supply, by F. H. Newell, illustrated by a large map showing the relative extent and location of the vacant public lands; also a report on the water resources of a portion of the Great Plains, by Robert Hay.

A geological reconnoissance of northwestern Wyoming, by George H. Eldridge, 1894; octavo, 72 pp. Bulletin No. 119 of the United States Geological Survey; price, 10 cents.

Contains a description of the geologic structure of portions of the Big Horn Range and Big Horn Basin, especially with reference to the coal fields, and remarks upon the water supply and agricultural possibilities.

Report of progress of the division of hydrography for the calendar year 1893–94, by F. H. Newell, 1895; octavo, 176 pp. Bulletin No. 131 of the United States Geological Survey; price, 15 cents.

Contains results of stream measurements at various points, mainly within the arid region, and records of wells in a number of counties in western Nebraska, western Kansas, and eastern Colorado.

1896.

Seventeenth Annual Report of the United States Geological Survey, 1895–96, Part II, Economic geology and hydrography, 1896; octavo, 864 pp.

Contains papers, on "The underground water of the Arkansas Valley in eastern Colorado," by G. K. Gilbert; "The water resources of Illinois," by Frank Leverett; and "Preliminary report on the artesian areas of a portion of the Dakotas," by N. H. Darton.

Artesian-well prospects in the Atlantic Coastal Plain region, by N. H. Darton, 1896; octavo, 230 pp., 19 plates. Bulletin No. 138 of the United States Geological Survey; price, 20 cents.

Gives a description of the geologic conditions of the coastal region from Long Island, N. Y., to Georgia, and contains data relating to many of the deep wells.

Report of progress of the division of hydrography for the calendar year 1895, by F. H. Newell, hydrographer in charge, 1896; octavo, 356 pp. Bulletin No. 140 of the United States Geological Survey; price, 25 cents.

Contains a description of the instruments and methods employed in measuring streams and the results of hydrographic investigations in various parts of the United States.

1897.

Eighteenth Annual Report of the United States Geological Survey, 1896–97, Part IV, Hydrography, 1897; octavo, 756 pp.

Contains a "Report of progress of stream measurements for the year 1896," by Arthur P. Davis; "The water resources of Indiana and Ohio," by Frank Leverett; "New developments in well boring and irrigation in South Dakota," by N. H. Darton; and "Reservoirs for irrigation," by J. D. Schuyler.

WATER-SUPPLY AND IRRIGATION PAPERS, 1896–1898.

This series of papers is designed to present in pamphlet form the results of stream measurements and of special investigations. A list of these, with other information, is given on the outside (or fourth) page of this cover.

Survey bulletins can be obtained only by prepayment of cost, as noted above. Postage stamps, checks, and drafts can not be accepted. Money should be transmitted by postal money order or express order, made payable to the Director of the United States Geological Survey. Correspondence relating to the publications of the Survey should be addressed to **The Director, United States Geological Survey, Washington, D. C.**

WATER-SUPPLY AND IRRIGATION PAPERS.

1. Pumping water for irrigation, by Herbert M. Wilson, 1896.
2. Irrigation near Phœnix, Arizona, by Arthur P. Davis, 1897.
3. Sewage irrigation, by George W. Rafter, 1897.
4. A reconnoissance in southeastern Washington, by Israel C. Russell, 1897.
5. Irrigation practice on the Great Plains, by E. B. Cowgill, 1897.
6. Underground waters of southwestern Kansas, by Erasmus Haworth, 1897
7. Seepage waters of northern Utah, by Samuel Fortier, 1897.
8. Windmills for irrigation, by E. C. Murphy, 1897.
9. Irrigation near Greeley, Colorado, by David Boyd, 1897.
10. Irrigation in Mesilla Valley, New Mexico, by F. C. Barker, 1898.
11. River heights for 1896, by Arthur P. Davis, 1897.
12. Water resources of southeastern Nebraska, by Nelson Horatio Darton, 1898.
13. Irrigation systems in Texas, by William Ferguson Hutson, 1898.
14. New tests of certain pumps and water lifts used in irrigation, by O. P. Hood, 1898.
15. Operations at river stations, 1897, Part I, 1898.
16. Operations at river stations, 1897, Part II, 1898.

In addition to the above, there are in various stages of preparation other papers relating to the measurement of streams, the storage of water, the amount available from underground sources, the efficiency of windmills, the cost of pumping, and other details relating to the methods of utilizing the water resources of the country. Provision has been made for printing these by the following clause in the sundry civil act making appropriations for the year 1896–97:

Provided, That hereafter the reports of the Geological Survey in relation to the gauging of streams and to the methods of utilizing the water resources may be printed in octavo form, not to exceed 100 pages in length and 5,000 copies in number; 1,000 copies of which shall be for the official use of the Geological Survey, 1,500 copies shall be delivered to the Senate, and 2,500 copies shall be delivered to the House of Representatives, for distribution. (Approved, June 11, 1896; Stat. L., vol. 29, p. 453.)

The maximum number of copies available for the use of the Geological Survey is 1,000. This number falls far short of the demand, so that it is impossible to meet all requests. Attempts are made to send these pamphlets to persons who have rendered assistance in their preparation through replies to schedules or who have furnished data. Requests made for a certain paper and stating a reason for asking for it are granted whenever practicable, but it is impossible to comply with general demands, such as to have all of the series sent indiscriminately.

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OPERATIONS AT RIVER STATIONS, 1897.—PART I

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CHARLES D. WALCOTT, DIRECTOR

OPERATIONS AT RIVER STATIONS, 1897

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, February 10, 1898.

SIR: I have the honor to transmit herewith brief descriptions of the river stations at which work was carried on by the Division of Hydrography of this Survey during 1897, together with tables of daily height.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

OPERATIONS AT RIVER STATIONS, 1897.

LAMBERTVILLE STATION ON DELAWARE RIVER.

Observations of height of Delaware River were begun on July 23, 1897, at the covered toll bridge at Lambertville, New Jersey, a town on the Belvidere Division of the Pennsylvania Railroad, 16 miles above Trenton. When visited, there was found to be an old gage on the bridge pier; later in the season the water receded below the end of this scale. A new gage was therefore put in place, consisting of a stamped link brass chain 33 feet long with a 6-pound sash weight attached. The chain runs over a pulley, the scale being a horizontal board 22 feet in length, graduated to tenths of a foot, fastened to the studding ot the bridge and inclosed in a wooden cover. The zero of the gage chain is marked by a copper rivet. It reads 2 feet when the water is at zero on the old gage of the bridge pier. The observer is Charles H. Naylor, collector of toll. Measurements are made from the windows of this covered bridge. The initial point for soundings is on the left bank. The channel above and below is nearly straight, the water being sluggish for a short space on the left side. The right bank is high and the bed of the stream is of gravel and sand. A measurement was made on July 22, 1897, by Arthur P. Davis, when the water stood at 5.50 feet on the new gage, the discharge being 21,831 second-feet; and another on September 14, 1897, by E. G. Paul, when the gage height was 3.42 feet and the discharge 5,308 second-feet.

Daily gage height, in feet, of Delaware River at Lambertville, New Jersey, for 1897.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug	Sept.	Oct.	Nov.	Dec.
1	.....	6.70	3.74	2.75	2.35	5.35	17	.....	4.45	2.95	3.35	4.40	9.00
2	.....	6.13	3.83	2.60	3.90	5.00	18	.....	4.25	2.75	3.05	4.50	7.60
3	.....	5.58	4.00	2.65	5.40	4.75	19	.....	4.16	2.85	2.75	4.45	6.85
4	.....	5.17	3.95	2.50	5.15	4.55	20	.....	4.04	2.50	2.50	4.35	6.20
5	.....	5.74	4.08	2.40	4.90	5.35	21	.....	3.91	2.55	2.45	4.25	5.60
6	.....	5.87	3.91	2.30	4.40	6.00	22	.....	3.87	2.60	2.40	4.20	5.40
7	.....	5.37	3.87	2.20	4.15	7.00	23	5.50	4.00	2.65	2.45	4.10	5.25
8	.....	5.04	3.70	2.20	3.95	6.10	24	5.25	4.17	2.75	2.60	4.10	5.25
9	.....	4.78	3.38	2.20	3.90	5.60	25	5.00	4.33	3.05	2.60	4.05	4.90
10	.....	4.52	3.00	2.20	4.15	5.40	26	4.92	5.20	3.25	2.55	3.95	4.50
11	.....	4.70	3.00	2.20	4.45	5.20	27	4.83	5.08	3.10	2.70	4.75	4.60
12	.....	4.83	3.87	2.30	4.60	5.20	28	6.12	4.69	3.40	2.55	6.20	4.50
13	.....	4.91	3.63	2.65	4.65	5.45	29	7.46	4.25	3.10	2.35	6.35	Frozen.
14	.....	4.95	3.41	3.20	4.70	6.35	30	8.75	3.95	2.85	2.30	5.65	4.20
15	.....	4.70	*a*3.17	3.35	4.50	8.25	31	7.75	3.74	.....	2.25	.....	4.25
16	.....	4.81	2.90	3.45	4.35	10.15							

a New gage erected. Former reading changed to refer to new datum.

HARRISBURG STATION ON SUSQUEHANNA RIVER.

Observations of the height of water in the Susquehanna River have been made for several years at the pump house of the waterworks, located in the western part of the city of Harrisburg, Pennsylvania. This well is connected directly with the river by means of large water mains. A float in this well is attached to a cable and counterweight, the height of water being indicated upon a painted scale. The datum is the low-water mark of 1804. Observations are made by the engineer, C. M. Nagle, each morning before starting the pumps. The record since 1890 has been furnished by Mr. E. Mather, president of the Harrisburg Water Company. Measurements of the discharge are made from the open iron bridge on Second street. The initial point for sounding is the iron upright at the east end of the bridge. The channel above and below the station is straight for about 2,500 feet. The banks are high and the current has moderate velocity. The stream is divided into two channels, with a large island between. The first measurement was made on March 31, 1897, by E. G. Paul.

The results of measurements during 1897 are as follows:

March 31, gage height, 5.42 feet; discharge, 58,859 second-feet.
May 15, gage height, 7.83 feet; discharge, 105,888 second-feet.
August 31, gage height, 1.50 feet; discharge, 9,568 second-feet.
September 16, gage height, 0.58 feet; discharge, 3,962 second-feet.
November 17, gage height, 2.50 feet; discharge, 17,824 second-feet.

Daily gage height, in feet, of Susquehanna River at Harrisburg, Pennsylvania, for 1891.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.83	10.58	11.00	8.25	3.58	2.00	2.75	3.25	4.67	1.75	2.50	4.25
2	3.00	11.50	9.00	9.00	3.50	1.92	2.50	3.17	4.00	1.67	2.50	4.00
3	3.33	11.50	7.33	8.58	3.42	2.00	2.58	3.08	3.67	1.67	2.33	3.67
4	4.50	11.17	6.67	8.75	3.42	2.00	3.17	2.92	3.33	1.58	2.25	3.50
5	5.25	10.17	5.67	8.42	3.25	2.00	4.08	3.00	3.00	1.58	2.25	4.58
6	5.00	8.92	5.67	8.00	3.08	2.00	3.50	3.08	3.00	1.58	2.25	8.75
7	5.50	7.67	5.25	7.17	3.00	2.08	3.08	3.00	3.83	1.58	2.17	9.50
8	5.42	7.50	5.00	6.42	3.00	2.17	2.67	3.33	4.67	1.75	2.17	8.33
9	4.92	7.50	4.67	6.00	2.92	2.58	2.75	3.08	4.50	2.58	2.00	7.00
10	4.50	7.42	4.67	5.67	2.75	2.75	2.67	2.83	4.08	3.00	2.00	6.00
11	4.08	7.50	6.17	5.33	2.67	3.00	2.92	2.75	3.83	2.83	2.00	5.42
12	4.25	7.42	7.08	6.08	2.67	2.75	2.83	2.58	3.50	2.67	2.67	5.00
13	6.00	7.00	8.50	7.33	2.58	2.67	2.75	2.58	3.08	2.67	3.67	4.17
14	8.75	6.42	9.67	9.00	2.50	2.67	2.50	2.58	3.00	2.58	4.00	4.33
15	7.92	5.92	10.75	8.50	2.50	2.58	2.25	2.50	3.00	2.42	4.25	4.00
16	7.50	5.58	10.00	8.00	2.42	2.50	2.17	2.50	2.67	2.33	4.08	3.83
17	6.67	5.92	8.83	7.67	2.42	2.42	2.00	2.50	2.67	2.08	3.75	3.75
18	6.00	14.25	7.75	7.42	2.33	2.33	1.83	2.42	2.58	2.00	4.00	3.67
19	5.67	19.00	6.83	6.83	2.25	2.33	1.92	2.25	2.58	1.63	4.83	4.58
20	5.08	17.83	6.17	6.75	2.25	2.33	2.08	2.42	2.50	1.92	4.75	5.00
21	4.83	13.25	5.92	6.33	2.04	3.33	2.08	2.25	2.25	2.17	4.67	4.75
22	4.50	11.75	6.33	5.92	2.00	3.58	2.08	2.08	2.17	2.50	4.25	4.17
23	7.08	11.50	6.67	5.50	2.13	5.42	2.00	2.00	2.08	3.25	4.17	3.83
24	9.17	10.25	8.08	5.17	2.25	6.17	2.00	3.08	2.08	4.67	4.08	3.92
25	9.50	9.00	10.33	5.00	2.33	5.58	4.33	6.50	2.00	4.17	5.42	4.58
26	9.42	8.25	10.83	4.75	2.29	4.58	4.00	6.58	1.92	3.67	6.42	6.33
27	8.42	11.33	10.08	4.67	2.25	4.33	3.83	5.25	1.83	3.17	6.17	8.25
28	7.50	13.08	8.92	4.25	2.21	3.75	3.33	5.67	1.75	3.00	5.42	9.33
29	7.00	.....	7.83	4.08	2.17	3.50	3.00	6.00	1.75	2.83	5.00	8.58
30	7.08	.....	7.50	3.83	2.08	3.50	2.75	5.33	1.75	2.67	4.67	7.83
31	9.83	.....	7.67	.....	2.00	.....	3.92	5.17	.....	2.58	.....	8.50

Daily gage height, in feet, of Susquehanna River at Harrisburg, Pennsylvania, for 1892.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	8.50	2.83	4.50	9.75	3.00	5.92	4.67	1.92	2.92	1.08	0.50	1.92
2	8.25	2.92	4.00	9.00	2.83	5.50	4.33	2.00	2.50	1.25	.50	1.83
3	8.75	2.92	3.58	8.50	2.83	5.17	3.75	1.83	2.33	1.42	.50	1.75
4	9.33	3.08	3.25	11.75	2.83	7.58	3.67	2.00	2.17	1.25	.50	1.58
5	8.83	3.08	3.00	14.33	4.50	12.50	3.50	3.00	2.00	1.08	.50	1.58
6	8.00	3.00	2.67	14.67	5.83	12.00	3.58	2.83	1.83	1.08	.50	1.50
7	7.83	3.00	2.83	13.17	7.58	11.25	3.42	2.83	1.83	1.00	.50	1.50
8	6.83	2.92	2.83	11.33	7.58	9.00	3.42	3.00	1.75	1.00	.50	1.50
9	5.33	2.75	3.83	9.50	7.83	7.67	3.42	2.67	1.67	1.00	.75	1.58
10	5.67	2.50	5.25	7.83	6.67	7.00	3.00	2.42	1.50	1.00	.92	1.67
11	4.17	2.58	6.17	7.00	5.58	7.42	2.83	2.17	1.50	1.00	1.00	2.42
12	3.67	2.50	5.92	6.42	5.00	7.00	2.50	2.08	1.42	.92	1.17	4.25
13	3.75	2.00	5.67	5.67	4.75	6.42	2.17	2.42	1.42	.92	1.17	4.00
14	5.50	1.08	5.00	5.33	4.25	5.42	2.17	2.50	1.50	.83	1.17	3.50
15	11.83	1.75	4.42	4.75	4.17	4.67	2.33	3.50	2.33	.83	1.25	3.08
16	13.17	1.83	4.00	4.75	4.17	4.17	2.42	4.17	2.33	.83	1.25	2.83
17	10.83	1.67	3.50	4.33	4.42	3.75	2.42	4.00	2.08	.83	1.25	2.92
18	9.08	1.75	3.33	4.33	4.83	3.58	2.25	3.50	1.83	.83	1.25	2.67
19	7.75	2.00	3.08	4.00	4.92	3.50	2.25	2.83	1.67	.83	1.92	2.58
20	7.67	2.33	3.00	3.83	5.67	3.50	2.08	2.67	1.50	.83	2.50	2.50
21	7.00	2.17	2.92	3.67	7.25	3.67	2.00	2.33	1.50	.83	2.50	2.42
22	6.17	2.50	2.67	3.50	8.25	4.00	1.75	2.17	1.50	.83	2.92	2.08
23	5.33	2.67	2.50	3.42	8.83	3.67	1.67	1.92	1.33	.83	3.58	1.50
24	4.75	3.17	2.50	3.50	8.75	3.50	1.67	1.83	1.17	.83	3.33	.92
25	4.50	3.50	2.67	3.50	8.25	3.67	1.67	1.92	1.17	.75	2.92	1.08
26	4.33	4.33	3.50	3.58	7.33	4.17	1.58	2.17	1.25	.58	2.50	2.58
27	3.58	4.50	4.50	3.58	6.67	3.58	1.50	2.00	1.25	.58	2.08	2.00
28	2.50	4.83	10.83	3.50	6.50	3.25	1.50	2.00	1.25	.58	2.00	2.25
29	2.08	4.67	13.00	3.33	6.33	3.50	1.50	2.00	1.08	.58	2.00	2.25
30	2.83	.....	12.00	3.17	7.08	4.83	1.42	2.25	1.08	.58	1.92	2.25
31	2.83	.....	10.58	.....	6.42	.....	1.67	3.00	.....	.50	.....	2.17

Daily gage height, in feet, of Susquehanna River, at Harrisburg, Pennsylvania, for 1893.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.00	2.67	2.58	6.08	4.92	3.67	2.33	0.92	3.58	2.00	2.17	4.00
2	2.50	3.00	2.58	6.00	4.83	3.67	2.17	.83	4.17	2.00	2.17	3.83
3	2.83	4.00	2.75	6.42	5.50	3.50	2.08	.83	3.92	1.83	2.17	3.67
4	2.83	4.17	2.75	7.50	6.83	3.58	1.92	.83	3.50	1.67	2.17	3.67
5	2.75	5.00	2.75	7.92	16.17	3.58	1.92	.75	2.67	1.50	2.33	3.67
6	2.67	5.08	2.50	8.92	16.50	3.17	1.67	.75	2.25	1.50	3.00	3.50
7	2.50	5.00	2.50	9.50	14.58	3.00	1.67	.67	2.00	1.42	3.25	3.17
8	2.50	5.33	2.67	8.83	12.00	3.00	1.58	.67	1.75	1.42	2.83	3.00
9	2.50	5.42	3.08	8.00	9.92	3.00	1.50	.58	1.67	1.42	2.75	3.00
10	2.50	6.42	6.50	8.42	8.25	2.83	1.50	.58	1.50	1.33	2.50	2.92
11	2.25	7.75	12.50	10.00	7.00	2.67	1.50	.50	1.50	1.33	2.50	2.83
12	2.25	11.58	13.83	9.42	6.17	2.58	1.50	.50	1.67	1.33	2.42	2.83
13	2.08	7.50	14.50	8.42	5.50	2.50	1.50	.42	2.00	1.25	2.33	2.83
14	2.08	6.50	14.58	7.75	5.00	2.33	1.50	.42	2.00	1.67	2.17	2.50
15	2.08	5.58	13.00	7.42	4.75	2.08	1.75	.42	1.83	4.67	2.08	2.00
16	2.00	5.25	12.25	8.08	4.58	2.00	1.83	.33	2.00	5.33	2.00	2.25
17	2.00	7.75	10.50	8.83	5.92	1.92	1.83	.33	2.50	5.25	1.92	2.42
18	2.00	6.75	8.83	8.92	8.50	1.83	1.67	.33	2.67	4.25	1.83	5.75
19	2.00	5.83	7.33	7.75	9.75	1.75	1.67	.33	4.42	3.83	1.75	8.83
20	2.00	5.33	6.67	6.92	9.00	1.75	1.67	.67	3.67	3.42	1.75	7.08
21	2.00	4.67	5.92	7.00	7.58	1.75	1.67	.58	3.25	3.00	1.67	6.00
22	2.00	4.25	5.58	10.00	7.00	1.58	1.50	.50	2.83	2.50	1.58	5.92
23	2.00	3.50	5.67	10.92	6.25	1.58	1.42	.42	2.50	2.50	1.58	4.42
24	2.00	3.00	6.83	10.50	5.58	1.75	1.33	.42	2.33	2.33	1.67	3.92
25	2.00	3.00	7.25	8.92	5.42	1.75	1.25	.33	2.33	2.25	1.67	3.83
26	2.00	3.00	7.75	7.67	4.92	2.00	1.17	.42	2.17	2.25	1.58	3.83
27	2.00	2.92	9.42	6.83	4.50	2.25	1.08	.50	2.00	2.25	1.58	4.83
28	2.00	2.75	8.67	6.17	4.33	2.50	1.08	.50	2.00	2.00	1.75	5.92
29	2.00	.....	7.83	5.67	4.17	2.75	1.83	1.00	2.00	2.00	2.83	5.83
30	2.33	.....	7.83	5.17	3.92	2.50	.92	3.00	2.00	2.00	3.67	5.17
31	2.50	.....	6.50	.....	3.67	.....	.92	3.08	.....	2.17	.....	4.67

Daily gage height, in feet, of Susquehanna River at Harrisburg, Pennsylvania, for 1894.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.5	2.41	3.16	3.83	4.58	9.50	2.58	1.08	0.33	1.91	5.08	2.41
2	4.5	2.33	3.33	3.66	4.50	9.66	2.41	1.08	.33	1.83	5.25	2.33
3	4.0	2.25	3.50	3.50	4.16	9.16	2.33	1.33	.33	1.58	5.41	2.50
4	3.66	2.16	3.75	3.25	3.83	8.58	2.25	1.50	.33	1.58	7.50	2.91
5	3.5	2.08	4.08	3.16	3.50	8.41	2.00	1.66	.25	1.41	7.66	3.50
6	3.33	2.00	5.66	3.00	3.16	7.91	2.00	1.58	.25	1.41	7.58	3.58
7	3.41	2.00	7.66	2.91	3.25	6.75	1.83	1.50	.33	1.33	7.16	3.58
8	5.16	2.00	11.33	2.83	3.33	6.00	1.83	1.50	.33	1.33	7.00	3.33
9	5.25	2.08	12.16	2.75	3.50	5.50	1.75	1.08	.41	1.25	6.50	3.00
10	4.58	3.50	10.83	2.75	3.50	5.00	1.66	1.08	1.00	1.33	6.00	3.00
11	3.75	5.00	8.50	2.83	3.50	4.66	1.58	1.08	1.91	2.08	5.50	3.33
12	3.33	6.00	9.83	3.00	3.08	4.00	1.50	1.00	1.50	4.91	5.33	4.00
13	2.50	5.66	7.16	3.25	2.91	3.75	1.41	1.00	1.33	5.58	4.66	4.33
14	3.16	4.58	7.00	3.66	2.75	3.66	1.41	1.00	1.25	5.08	4.50	5.75
15	3.16	4.33	6.41	6.33	2.50	3.66	1.33	1.00	1.25	4.66	4.00	6.16
16	2.83	3.66	5.83	7.58	2.50	3.58	1.33	1.00	1.16	4.16	3.91	6.33
17	2.66	3.33	5.50	9.08	2.33	3.41	1.25	1.00	1.08	3.83	3.66	5.75
18	2.83	3.33	5.08	9.08	2.33	3.16	1.16	1.00	1.08	3.66	3.50	5.16
19	2.83	3.33	4.83	8.50	2.33	3.00	1.08	.91	2.16	3.41	3.25	4.66
20	3.00	4.16	4.58	7.50	5.33	3.50	1.08	.91	4.08	3.00	3.16	4.33
21	2.83	5.66	4.50	6.75	16.33	3.41	1.08	.83	5.00	2.75	3.08	4.08
22	2.83	5.33	4.33	8.50	25.58	3.08	1.08	.83	5.50	2.50	3.25	3.83
23	2.58	5.16	4.50	9.41	21.41	2.83	1.00	.75	5.66	2.33	3.16	3.58
24	2.41	4.33	4.66	9.58	15.25	2.50	1.08	.75	4.83	2.16	3.00	3.50
25	2.41	3.33	5.50	9.91	11.83	2.50	1.25	.75	4.00	2.33	3.00	3.33
26	2.41	2.91	7.00	9.00	11.33	2.66	1.41	.75	3.41	3.58	2.83	3.08
27	2.41	2.33	6.33	7.25	11.66	2.58	1.50	.66	3.00	4.75	2.66	3.00
28	2.50	2.50	5.50	6.00	9.50	2.66	1.50	.66	2.58	4.83	2.58	3.00
29	2.58	.....	4.91	5.41	7.91	2.41	1.41	.58	2.25	4.33	2.58	4.00
30	2.58	.....	4.33	5.00	7.00	2.75	1.16	.50	2.08	4.00	2.50	3.66
31	2.50	.....	4.00	.....	7.50	.....	1.08	.41	.....	3.75	.....	3.66

Daily gage height, in feet, of Susquehanna River at Harrisburg, Pennsylvania, for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.92	2.92	6.00	5.75	3.42	2.67	2.83	0.58	0.75	0.42	0.21	3.08
2	4.00	2.83	8.58	5.67	3.33	2.58	2.67	.67	.75	.42	.21	3.08
3	4.25	3.00	8.08	6.17	3.25	2.50	2.92	.67	.67	.33	.25	2.75
4	4.33	3.00	10.50	6.83	3.00	2.25	2.50	.67	.67	.33	.25	2.50
5	4.33	7.00	7.83	6.67	2.75	2.08	2.25	.58	.58	.33	.33	2.25
6	4.33	5.67	7.67	6.17	2.67	1.92	2.00	.50	.58	.33	.38	2.00
7	4.33	5.75	6.67	6.00	2.50	1.83	1.92	.50	.75	.33	.38	1.92
8	4.50	5.67	6.25	5.75	2.42	1.75	1.75	.83	.75	.25	.42	1.92
9	4.75	5.50	5.83	8.08	2.25	1.75	1.58	.75	.67	.25	.42	1.92
10	6.17	5.50	6.17	12.00	2.75	1.58	1.50	1.00	.50	.21	.42	1.83
11	7.42	5.58	6.17	13.67	3.00	1.33	1.50	1.08	1.00	.21	.42	.50
12	7.83	5.92	6.33	12.50	3.33	1.42	1.42	1.08	1.50	.21	.46	1.50
13	8.50	5.83	6.17	10.92	3.67	1.33	1.33	1.08	1.58	.33	.50	.96
14	7.83	5.83	6.00	9.50	4.33	1.25	1.33	.92	1.42	.29	.58	.75
15	6.75	5.67	6.50	10.00	4.33	1.25	1.25	1.33	1.00	.29	.58	1.00
16	6.25	5.58	6.75	9.75	4.17	1.25	1.25	1.33	.83	.25	.58	1.00
17	5.75	5.50	6.67	8.75	4.08	1.25	1.08	1.08	.67	.25	.67	1.33
18	5.42	5.50	6.33	7.58	3.67	1.25	1.00	1.00	.58	.42	.83	1.33
19	5.00	5.33	5.67	6.67	3.50	1.25	.92	1.00	.67	.58	1.00	1.33
20	4.50	5.25	5.50	6.00	3.33	1.25	.92	.92	.67	.50	1.00	1.33
21	4.42	5.17	5.33	5.50	3.17	1.17	.83	.83	.67	.42	.92	1.50
22	4.33	5.08	5.17	5.00	3.08	1.00	.83	.58	.58	.42	.79	1.83
23	4.00	5.00	5.00	4.58	2.92	.75	.83	.50	.58	.33	.67	2.00
24	4.00	4.92	5.00	4.33	2.75	.75	.83	.50	.58	.25	.75	2.67
25	3.33	4.75	5.00	4.00	2.58	.75	.83	.42	.58	.25	.75	2.75
26	3.25	4.58	5.83	3.75	2.50	1.50	.83	.33	.50	.21	.75	2.83
27	3.08	4.50	8.00	3.58	2.50	1.50	.83	.33	.50	.13	.75	3.33
28	3.08	4.75	9.00	3.75	2.42	1.50	.83	.33	.42	.08	2.67	3.50
29	3.08	.....	8.00	3.75	2.42	2.00	.75	.33	.42	.08	2.83	5.08
30	3.25	.....	7.17	3.50	3.08	3.50	.58	.33	.42	.04	2.83	5.67
31	3.00	.....	6.33	.....	3.00	.....	.42	.50	.....	.04	.....	5.67

Daily gage height, in feet, of Susquehanna River at Harrisburg, Pennsylvania, for 1896.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	9.92	4.50	7.17	14.58	3.00	1.50	2.67	4.67	0.33	5.42	2.08	3.92
2	9.17	3.75	9.17	14.58	3.00	1.50	2.42	4.33	.33	4.25	1.92	3.92
3	8.42	3.58	9.75	13.75	2.83	1.75	2.08	3.83	.33	4.00	1.83	3.83
4	6.50	3.58	8.42	12.33	2.83	1.83	1.83	3.75	.33	3.17	1.83	3.33
5	5.08	3.50	7.17	10.50	2.67	1.67	1.75	3.67	.25	2.67	1.83	3.00
6	4.00	4.00	5.50	8.83	2.50	1.67	1.67	3.58	.25	2.08	7.25	2.75
7	3.83	11.50	5.00	7.25	2.42	1.67	2.17	2.50	.25	1.83	10.08	2.67
8	3.00	12.50	4.75	6.50	2.17	1.58	2.00	2.33	.25	1.67	7.75	2.50
9	4.67	10.33	4.50	6.17	2.08	1.42	1.92	2.33	.25	1.50	6.50	2.50
10	4.33	8.50	4.83	5.83	2.00	1.75	2.33	2.25	.25	1.50	5.67	2.67
11	4.08	6.83	5.08	5.50	2.00	2.50	2.75	2.25	.25	1.50	4.75	3.42
12	4.00	5.33	4.67	5.50	1.92	2.58	2.75	2.00	.25	1.50	4.42	3.75
13	3.92	4.92	4.00	6.00	1.75	3.42	2.50	1.83	.25	1.92	4.17	4.00
14	4.00	4.25	3.50	6.42	1.67	3.25	2.17	1.67	.33	7.33	4.00	4.25
15	3.83	3.75	2.67	8.00	1.67	2.92	2.00	1.67	.33	7.00	3.83	3.83
16	3.83	3.75	2.67	8.42	1.75	2.58	1.83	1.58	.33	9.50	3.67	3.67
17	3.75	3.83	2.33	8.17	1.58	2.58	1.67	1.58	.50	7.67	3.50	3.42
18	3.58	3.58	2.50	7.33	1.50	2.83	1.58	1.58	.50	5.58	3.33	3.08
19	3.67	2.92	3.17	6.83	1.50	2.67	1.67	1.33	.58	4.83	3.17	2.92
20	4.00	3.00	4.00	6.33	1.50	3.00	1.67	1.25	.58	4.08	3.00	2.58
21	3.67	2.33	6.00	5.75	1.50	3.17	1.92	1.00	.67	3.58	2.83	2.33
22	3.50	3.67	5.75	5.25	1.42	3.00	1.67	.83	.83	3.42	2.67	2.00
23	3.50	5.42	5.75	4.83	1.42	2.42	1.58	.83	1.17	3.25	2.58	2.00
24	3.50	5.42	6.25	4.58	1.42	2.33	1.67	.83	1.17	3.00	2.50	1.50
25	4.00	3.42	5.58	4.33	1.33	2.25	1.67	.83	.92	3.00	2.50	1.50
26	7.25	3.50	5.00	4.08	1.25	2.67	1.75	.75	.75	3.00	2.33	1.50
27	7.33	3.67	5.25	4.00	1.17	4.75	1.92	.75	.58	2.75	2.33	1.50
28	6.17	3.17	6.08	3.58	1.25	4.00	2.50	.67	.50	2.67	2.42	1.50
29	6.00	3.17	6.50	3.42	1.50	3.50	2.50	.58	.42	2.50	2.67	1.33
30	5.75	.....	9.25	3.25	1.50	3.08	3.75	.50	.83	2.42	3.50	1.58
31	5.42	.....	12.50	.....	1.50	.....	4.33	.33	.....	2.25	.....	1.75

Daily gage height, in feet, of Susquehanna River at Harrisburg, Pennsylvania, for 1897

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.83	3.33	4.25	5.00	3.08	2.92	1.42	4.00	1.25	1.75	0.67	5.00
2	2.00	3.17	3.67	4.67	3.08	2.83	1.33	4.33	1.08	1.50	1.17	4.50
3	2.00	3.17	3.25	4.33	5.50	2.67	1.25	3.83	1.00	1.33	3.08	4.00
4	2.08	3.17	3.83	4.17	6.50	2.58	1.25	3.25	1.00	1.17	4.08	3.75
5	2.50	3.08	4.92	4.00	7.50	2.67	1.25	2.83	1.00	1.08	3.50	3.33
6	3.00	3.00	5.92	3.83	7.08	3.00	1.25	2.67	.92	1.00	3.08	4.75
7	3.67	4.25	7.67	3.75	7.00	2.67	1.42	2.42	.83	1.00	3.00	5.17
8	3.67	7.50	8.58	3.75	6.33	2.50	1.42	2.67	.83	.92	2.75	5.08
9	3.67	6.58	8.00	3.75	5.50	2.67	1.25	2.50	.83	.83	2.50	5.42
10	3.33	5.42	6.92	5.92	4.83	2.67	1.25	2.08	.83	.67	2.50	4.92
11	3.08	4.83	6.50	9.00	4.50	2.67	1.17	2.08	.75	.67	2.67	4.33
12	2.83	4.50	7.25	9.50	4.00	2.67	1.08	2.00	.67	.58	2.67	4.17
13	2.42	3.92	8.67	8.00	4.00	3.00	1.00	1.83	.67	.75	2.50	4.17
14	2.00	3.83	8.42	6.83	6.00	3.50	1.08	1.75	.67	.75	2.50	4.33
15	2.00	3.83	7.75	6.00	7.75	3.25	1.00	1.58	.50	.75	2.50	4.58
16	2.00	3.50	7.00	6.00	7.92	2.92	1.00	1.58	.58	.75	2.50	6.58
17	2.00	3.50	6.92	6.58	7.33	2.67	1.17	1.50	.67	.67	2.50	7.67
18	2.17	3.33	5.50	7.00	6.50	2.50	1.17	1.50	.75	.67	2.67	8.17
19	2.33	3.58	5.00	6.58	5.75	2.25	1.08	1.42	.75	.58	2.92	7.33
20	2.00	4.08	5.33	6.00	5.00	2.17	1.08	1.42	.67	.58	3.42	6.33
21	1.83	4.00	7.42	5.50	4.25	2.17	1.50	1.33	.58	.50	3.25	5.58
22	1.83	4.25	8.25	4.92	4.00	2.17	1.50	1.17	.58	.58	3.17	5.00
23	1.92	5.92	9.75	4.50	3.58	2.00	1.33	1.17	.58	.75	2.83	4.08
24	1.67	7.92	9.50	4.17	3.50	1.83	1.33	1.25	1.00	.75	2.50	3.83
25	1.67	7.50	10.17	3.83	3.75	1.75	1.58	1.67	1.50	1.00	2.50	3.42
26	.50	6.50	11.50	3.67	3.75	1.75	1.75	2.67	1.50	1.00	2.50	2.83
27	3.33	5.50	10.67	3.58	3.50	1.67	1.75	2.08	1.83	1.00	2.33	2.75
28	3.33	4.50	8.00	3.50	3.58	1.58	2.17	1.75	1.92	.92	2.50	2.67
29	3.00	.....	7.42	3.33	3.92	1.58	3.83	1.58	2.25	.83	3.50	2.67
30	3.25	.....	6.33	3.17	3.50	1.50	4.50	1.50	2.00	.75	4.92	2.58
31	3.33	.....	5.58	.....	3.25	.....	4.08	1.33	.....	.75	.....	2.50

ROWLANDSVILLE STATION ON OCTORARO CREEK.

This station, described on page 16 of the Eighteenth Annual Report of this Survey, Part IV, was established November 21, 1896, at the wagon bridge in the village of Rowlandsville, Maryland. A wire gage was attached to the floor timber on the upper side of the bridge. The observer is Hugh W. Caldwell. The bench mark for the gage is a cross cut in top of capstone on the lower side of the bridge abutment on the left bank of the stream, and is 18.83 feet above the zero of the gage. Observations of height of water were begun at this point on November 22, 1896, the height during the remainder of that year ranging from 3 to 3.20 feet, except in the case of a flood on November 29 rising to 4.30 feet. The following measurements have been made by Hugh W. Caldwell:

November 21, 1896, gage height, 3.00 feet; discharge, 138 second-feet.
January 23, 1897, gage height, 3.42 feet; discharge, 248 second-feet.
July 21, gage height, 3.45 feet; discharge, 264 second-feet.
August 16, gage height, 3.10 feet; discharge, 175 second-feet.
August 31, gage height, 2.80 feet; discharge, 138 second-feet.
September 18, gage height, 2.90 feet; discharge, 136 second-feet.
October 22, gage height, 3.10 feet; discharge, 138 second-feet.
November 2, gage height, 6.00 feet; discharge, 1,843 second-feet.
November 3, gage height, 4.00 feet; discharge, 444 second-feet.

Daily gage height, in feet, of Octoraro Creek at Rowlandsville, Maryland, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.10	3.20	3.45	3.30	3.40	3.40	3.00	3.40	2.80	2.80	3.10	3.30
2	3.10	3.20	3.60	3.30	3.40	3.40	3.00	3.30	2.80	2.80	6.00	3.40
3	3.10	4.80	3.50	3.30	3.60	3.40	3.00	3.30	2.80	2.80	4.15	3.45
4	3.10	3.55	3.50	3.30	3.50	3.40	3.00	3.30	2.80	2.80	3.70	3.60
5	3.15	3.45	3.50	3.30	3.40	5.45	3.00	3.30	2.80	2.80	3.40	4.35
6	3.10	8.68	3.45	3.30	3.30	3.70	2.90	3.20	2.80	2.80	3.40	3.70
7	3.10	10.10	3.40	3.30	3.30	3.70	2.90	3.20	2.80	2.80	3.30	3.45
8	3.10	9.20	3.40	3.30	3.30	3.45	2.90	3.20	2.80	2.80	3.65	3.30
9	3.10	7.50	3.30	4.60	3.20	3.40	2.90	3.30	2.80	2.80	3.50	3.30
10	3.10	5.40	3.30	5.50	3.20	3.30	2.90	3.30	2.80	2.80	3.60	3.30
11	3.10	3.50	3.30	6.15	3.20	3.30	2.90	5.10	2.80	2.90	3.70	3.60
12	3.10	3.35	3.20	5.65	3.20	3.30	2.90	3.40	2.80	2.85	3.45	3.40
13	3.10	3.30	3.20	4.55	4.85	3.30	2.90	3.30	2.80	2.80	3.35	3.30
14	3.10	3.30	3.20	3.85	5.00	3.20	2.90	3.20	2.80	2.80	3.30	4.65
15	3.10	3.40	3.20	3.60	5.00	3.20	2.90	3.10	2.80	2.80	3.20	4.90
16	3.10	4.55	3.20	3.50	3.75	3.20	2.90	3.10	2.80	2.80	3.20	3.95
17	3.10	4.05	3.20	3.50	3.55	3.20	2.90	3.10	3:05	2.80	3.20	3.70
18	3.10	3.55	3.40	3.45	3.40	3.20	2.90	3.00	2.90	2.80	3.30	3.60
19	3.10	3.60	4.15	3.45	3.30	3.20	3.10	2.90	2.90	2.90	3.30	3.60
20	3.10	3.40	3.60	3.40	3.30	3.20	3.10	2.90	2.90	2.90	3.30	3.50
21	6.70	3.45	3.40	3.30	3.40	3.20	3.75	3.05	2.80	3.00	3.20	3.50
22	6.65	3.45	3.40	3.30	3.65	3.20	3.85	3.05	2.80	3.05	3.20	3.40
23	4.45	6.00	3.40	3.20	3.40	3.10	3.55	3.00	3.20	3.20	3.20	3.30
24	3.30	3.80	4.20	3.20	3.40	3.10	3.40	3.00	3.20	3.20	3.20	3.30
25	3.20	3.45	3.95	3.20	5.05	3.10	3.30	3.00	3.10	3.20	3.20	3.30
26	3.20	3.35	3.55	3.20	4.80	3.10	3.30	3.00	3.00	3.20	3.20	3.35
27	3.20	3.40	3.40	3.20	3.90	3.10	4.25	2.90	3.00	3.20	4.85	3.50
28	3.20	3.40	3.30	3.20	3.50	3.10	3.95	2.90	3.00	3.10	4.10	3.50
29	3.20	.....	3.30	3.20	3.40	3.00	3.65	2.80	2.90	3.10	3.65	3.40
30	3.20	.....	3.30	3.20	3.40	3.00	3.50	2.80	2.80	3.00	3.40	3.40
31	3.20	.....	3.30	.....	3.40	.....	3.40	2.80	.....	3.00	.....	3.50

WOODSTOCK STATION ON PATAPSCO RIVER.

This station, described on page 16 of the Eighteenth Annual Report, Part IV, is located on the county bridge on the road from Woodstock to Granite, Maryland, a mile and a half below the junction with the North Branch. The pulley of the wire gage is fastened to the floor timber of the upper side of the bridge 40 feet from the initial point established for making soundings. The scale is a board spaced to tenths of a foot with small nails and nailed to the guard timber of the bridge. The channel at this point is rough and rocky, and is also liable to change in extreme high water. The bench mark is a United States Geological Survey standard copper bolt set in the face of the retaining wall of the entrance to the college grounds at the north end of the bridge. It is 22.06 feet above gage datum. The gage wire was renewed October 14, 1897. The observer is David Donovan.

The following measurements were made by E. G. Paul in 1897:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Dis. charge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Feb. 10	4.20	345	July 13	4.20	397	July 22	6.10	2,417
Mar. 9	4.10	297	July 20	3.80	239	Oct. 14	3.35	151
Apr. 10	4.60	582	July 22	9.30	5,466	Nov. 29	3.50	202
May 13	7.30	2,934	July 22	8.10	4,139	Dec. 15	4.70	714

Daily gage height, in feet, of Patapsco River at Woodstock, Maryland, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.80	3.60	4.05	3.85	3.90	4.05	3.75	3.85	3.35	3.20	3.80	3.80
2	3.70	3.60	4.05	3.85	4.00	4.05	3.75	3.95	3.25	3.25	10.70	3.75
3	3.50	5.00	4.15	3.90	4.15	4.20	3.75	3.95	3.30	3.15	3.75	3.75
4	3.60	4.60	4.05	3.70	4.30	4.15	3.70	3.75	3.20	3.15	4.00	4.05
5	3.85	4.70	4.05	4.70	4.25	5.05	3.70	3.70	3.35	3.25	3.85	5.00
6	3.90	9.60	4.15	4.40	4.10	4.05	3.75	3.75	3.30	3.20	3.80	4.35
7	3.90	6.45	4.15	4.15	4.00	.....	3.75	3.70	3.20	3.30	3.70	4.10
8	3.85	4.70	4.05	4.15	4.00	4.15	3.90	3.50	3.05	3.05	3.80	4.05
9	3.95	4.50	4.05	4.80	3.85	4.25	3.80	3.65	3.15	3.15	4.10	3.95
10	3.85	4.45	4.05	4.50	3.85	4.00	3.65	7.30	3.15	3.00	3.80	3.95
11	3.80	4.20	4.05	4.50	3.90	3.95	3.65	4.55	3.10	3.05	3.80	3.95
12	3.85	4.20	4.00	4.30	4.15	3.95	7.05	3.90	2.95	3.05	3.80	4.50
13	3.85	4.05	4.05	4.10	6.60	4.05	4.45	3.90	3.35	3.20	3.70	4.10
14	3.80	4.05	4.05	4.15	5.00	3.95	4.25	3.90	3.20	3.40	3.65	4.80
15	3.65	4.20	4.15	4.30	4.85	3.90	4.00	3.80	3.10	3.35	3.80	5.55
16	3.70	4.50	4.15	4.80	4.35	3.90	3.70	6.05	3.15	3.30	3.75	4.50
17	3.80	4.30	4.05	4.10	4.30	3.90	4.10	4.00	3.25	3.15	3.70	4.30
18	3.85	4.25	3.95	4.30	4.20	3.95	4.15	3.95	3.45	3.35	3.70	4.15
19	3.80	4.05	4.00	4.05	4.20	3.90	4.00	3.85	3.30	3.30	3.65	4.05
20	3.75	4.05	4.75	4.05	4.20	3.90	3.90	3.75	3.30	3.35	3.60	4.10
21	3.90	4.55	4.35	3.90	4.15	3.90	3.80	3.70	3.30	3.50	3.60	4.00
22	4.45	5.95	4.15	3.90	4.15	3.75	7.50	3.85	3.20	3.35	3.65	4.00
23	3.50	5.80	4.20	3.90	3.95	3.70	4.30	4.00	3.25	3.50	3.85	3.90
24	3.95	4.75	4.40	3.90	5.77	3.75	3.90	7.15	3.30	3.15	3.80	3.60
25	3.95	4.40	4.20	3.85	4.63	3.75	3.80	4.00	3.35	3.55	3.60	3.90
26	4.05	4.30	4.10	3.95	4.20	3.80	3.80	4.70	3.25	3.70	3.60	4.00
27	3.60	4.35	4.10	3.90	4.15	3.70	4.25	4.00	3.40	3.45	4.55	4.00
28	3.60	4.10	4.05	3.90	4.15	3.80	6.65	3.50	3.20	3.40	3.90	3.80
29	3.60	.....	3.95	3.80	4.05	3.75	5.10	3.25	3.25	3.40	3.85	3.80
30	3.60	.....	3.90	3.80	3.85	3.70	4.10	3.40	3.20	3.35	3.85	3.80
31	3.60	.....	3.95	.....	4.55	.....	4.00	3.45	.....	3.15	.....	3.90

LAUREL STATION ON PATUXENT RIVER.

This station, described on page 18 of the Eighteenth Annual Report of this Survey, Part IV, was established August 3, 1896, on the bridge on the main cross street of the town of Laurel, Maryland. The initial point for soundings is the end of iron truss, upper side. A wire gage with metal weight was attached to the lower side of the bridge, the scale being a 14-foot board spaced to tenths of a foot with small nails and fastened to the floor timber of the bridge. The bench mark is a copper bolt set in large capstone of the retaining wall on the lower side of the bridge abutment on the left bank of the stream. It is 21.22 feet above zero of gage height. The flow of water past this station in time of dry weather is confined to certain hours of the day, owing to a dam at the large cotton mill situated about 1 mile up the stream from the station. The observer is John H. Phair.

The following discharge measurements were made by E. G. Paul and others during 1897:

February 11, gage height, 5.40 feet; discharge, 184 second-feet.
February 23, gage height, 8.50 feet; discharge, 612 second-feet.
March 12, gage height, 4.40 feet; discharge, 155 second-feet.
May 25, gage height, 8.70 feet; discharge, 734 second-feet.
July 13, gage height, 7.85 feet; discharge, 539 second-feet.
July 22, gage height, 13.70 feet; discharge, 6,144 second-feet.
September 3, gage height, 4.10 feet; discharge, 63 second-feet.

Daily gage height, in feet, of Patuxent River at Laurel, Maryland, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.00	5.15	5.15	4.65	4.85	4.80	4.50	5.60	4.20	4.15	4.55	4.95
2	4.90	5.75	5.05	4.65	5.75	4.80	4.35	5.05	4.20	4.25	10.50	4.90
3	3.90	9.10	5.00	4.60	4.85	4.80	3.80	4.75	4.20	3.25	6.30	4.85
4	4.75	7.50	4.85	4.60	4.85	5.05	6.60	4.60	4.00	4.45	5.35	5.50
5	4.70	6.30	5.00	5.20	4.75	5.10	3.55	4.85	4.00	4.30	4.95	7.80
6	4.75	9.05	5.10	5.30	4.80	4.45	3.85	4.65	4.00	4.10	4.85	5.65
7	4.55	10.80	(a)	4.95	4.75	4.75	3.80	4.30	4.00	3.60	4.65	5.35
8	4.45	7.95	(a)	4.85	4.45	4.75	4.65	4.30	3.95	4.30	5.00	5.10
9	4.05	5.50	(a)	6.50	4.25	5.00	4.45	4.40	3.95	4.25	5.55	5.15
10	3.75	5.25	(a)	6.35	4.65	4.75	4.40	4.40	3.80	3.45	5.75	4.85
11	4.20	5.30	(a)	5.00	4.70	4.55	3.70	4.35	3.80	4.45	4.95	4.85
12	4.45	5.30	4.50	5.00	4.85	4.20	4.60	4.35	4.15	4.60	5.00	4.80
13	4.60	5.30	4.95	4.95	7.65	4.20	8.10	4.30	4.25	4.60	4.95	5.15
14	4.90	5.10	4.75	4.90	7.35	4.50	5.05	4.20	4.55	4.55	4.45	5.55
15	5.15	6.30	5.20	4.85	5.85	4.70	4.60	4.20	4.05	4.25	5.00	8.70
16	4.25	6.35	4.70	5.05	5.40	4.00	4.25	8.15	3.60	4.15	4.90	6.05
17	3.70	6.35	4.95	4.95	4.85	4.50	4.25	4.60	3.80	3.15	4.70	5.50
18	4.25	5.35	5.45	4.75	5.00	4.45	4.80	4.35	4.60	4.35	4.90	4.35
19	4.75	5.15	5.45	4.75	4.80	4.30	5.55	4.30	3.30	4.25	4.75	4.90
20	4.65	5.05	5.65	4.65	4.50	4.15	6.00	4.20	4.15	4.15	4.75	5.00
21	4.70	4.80	5.50	4.65	4.80	4.55	4.75	4.15	4.35	4.75	4.40	4.95
22	5.20	8.65	5.20	4.80	5.05	4.40	12.25	7.30	4.30	4.45	4.70	5.15
23	5.00	9.10	5.00	4.45	4.50	4.45	6.45	4.60	4.50	4.45	4.75	5.00
24	4.25	6.55	5.05	3.90	5.30	4.40	5.50	4.70	5.90	3.95	4.55	5.15
25	4.00	5.60	5.15	4.40	9.75	4.00	4.95	4.45	4.50	4.55	4.45	5.10
26	4.75	5.30	4.95	4.55	5.25	4.35	5.15	6.90	3.90	4.90	4.80	5.25
27	5.00	5.20	4.70	4.60	5.30	3.70	5.45	4.45	4.50	4.70	9.60	4.95
28	4.05	4.85	4.50	4.60	4.90	4.55	9.20	4.35	4.25	4.70	5.45	4.60
29	5.20	.....	4.75	4.80	4.65	4.50	5.90	4.20	4.30	4.45	5.30	4.75
30	5.20	.....	4.80	4.55	4.35	4.40	5.30	4.20	4.15	4.45	4.95	5.00
31	4.25	.....	4.50	.....	4.80	.....	4.95	4.90	.....	3.60	.....	4.95

a Gage down.

CUMBERLAND STATION ON POTOMAC RIVER.

This station, described on page 22 of the Eighteenth Annual Report of this Survey, Part IV, is 1,000 feet below the mouth of Wills Creek at Cumberland, Maryland. The river gage consists of a vertical rod 10 feet long, bolted to the east side of the abutment of the head gate of the eastern feeder of the Chesapeake and Ohio Canal just above the dam. The top of the rod, or the 10-foot mark, is 5.40 feet below the top of the abutment. Measurements of the river are made from the West Virginia Central Railroad bridge, about 200 yards below the dam across the Potomac. At high water the section is fairly smooth and the velocity high. At low water, rocks, riffles, and angular currents appear. Measurements of the canal feeders have also been made near the head gates.

The following discharge measurements were made by A. P. Davis, E. G. Paul, and G. H. Matthes during 1897:

February 10, gage height, 3.75 feet; discharge, 1,307 second-feet.
March 27, gage height, 3.93 feet; discharge, 1,995 second-feet.
June 25, gage height, 3.00 feet; discharge, 425 second-feet.
September 1, gage height, 2.60 feet; discharge, 86 second-feet.
September 22, gage height, 2.70 feet; discharge, 92 second-feet.

Daily gage height, in feet, of Potomac River at Cumberland, Maryland, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.20	3.40	4.00	3.50	3.50	2.90	2.70	3.00	2.60	2.20	2.80	.....
2	3.20	3.50	3.80	3.40	7.50	2.80	2.70	3.00	2.50	2.00	3.00	.....
3	3.30	3.60	3.90	3.40	5.50	2.80	2.70	2.90	2.50	1.90	3.00	.....
4	3.30	3.40	5.20	3.70	5.00	2.80	2.70	2.90	2.50	1.70	3.10	.....
5	4.00	3.40	4.90	3.80	4.60	2.80	2.70	3.50	2.40	1.70	3.00	.....
6	4.00	3.50	6.00	3.70	4.10	2.80	2.60	3.20	2.40	1.60	2.90	.....
7	3.70	4.50	5.00	3.60	4.10	2.80	2.60	3.10	2.20	1.50	2.90	.....
8	3.40	4.20	4.40	5.20	3.90	2.80	2.70	3.20	1.90	1.40	3.00	.....
9	3.30	4.00	4.60	5.40	3.70	2.90	2.70	3.10	1.80	1.40	4.00	.....
10	3.40	3.70	4.20	4.50	3.70	2.70	2.70	3.00	1.80	1.50	3.40	.....
11	3.20	3.60	4.00	4.50	3.60	2.70	2.80	3.00	1.70	1.30	3.40	.....
12	3.20	3.50	4.00	4.10	4.00	2.70	2.90	2.90	1.60	1.30	3.30	.....
13	3.20	3.70	3.90	4.00	4.40	2.60	2.90	2.90	1.50	1.30	3.20	.....
14	3.20	4.00	3.80	3.80	5.40	2.50	2.80	2.80	1.40	1.40	3.20	.....
15	3.20	4.20	4.00	3.90	4.60	2.50	2.80	3.00	1.30	1.50	3.50	.....
16	3.20	4.70	3.80	3.90	4.30	3.00	2.80	3.00	1.20	1.50	3.50	.....
17	3.40	4.50	3.70	3.70	3.90	3.00	2.70	2.90	1.20	1.40	3.40	.....
18	3.70	5.00	4.00	3.70	3.80	2.90	2.80	2.80	3.20	1.40	3.30	.....
19	3.50	4.80	4.50	3.60	3.70	2.90	2.80	2.90	3.00	1.40	3.30	.....
20	3.40	3.50	4.80	3.70	3.50	2.90	2.90	2.90	2.90	1.40	3.20	.....
21	3.40	3.50	4.60	3.50	3.30	3.00	3.20	2.90	2.80	1.40	.....	.....
22	3.50	10.50	4.20	3.30	3.30	3.00	3.00	2.90	2.70	1.30	.....	.....
23	3.40	8.70	4.00	3.30	3.30	2.90	3.00	2.90	2.60	1.30	.....	.....
24	3.40	6.20	4.20	3.30	3.00	2.90	3.00	2.90	2.80	1.50	.....	.....
25	3.30	5.10	4.10	3.20	3.00	3.00	3.00	2.90	3.00	1.60	.....	.....
26	3.30	4.50	4.00	3.10	3.00	2.90	2.90	3.00	3.00	1.60	.....	.....
27	3.30	4.30	3.90	3.00	3.00	2.90	3.20	3.00	2.90	1.70	.....	.....
28	3.30	4.00	3.80	3.00	3.00	2.90	3.10	3.00	2.80	1.70	.....	.....
29	3.30	.....	3.70	3.00	2.90	2.90	3.10	2.90	2.80	2.40	.....	.....
30	3.30	.....	3.60	2.90	2.90	2.80	3.10	2.80	2.70	2.70	.....	.....
31	3.30	.....	3.60	.....	2.90	.....	3.00	2.60	.....	2.70	.....	.....

SHARPSBURG STATION ON ANTIETAM CREEK.

The station is at Myers's mill, 1 mile east of Sharpsburg, Maryland, on the road to Keedysville, Maryland. It was established on June 24, 1897, by Arthur P. Davis. The observer is Evans M. Myers, a farmer living near the bridge. The equipment consists of a three-quarters inch steel cable with 85-foot span supported by large trees. The gage is driven into the gravel of the stream bed and bolted to an overhanging tree. The initial point for soundings is on the left bank. The channel both above and below the station is nearly straight for 300 feet, and the water moves with moderate velocity. The right bank is low and liable to overflow; the left is high and rocky. A measurement on June 24, 1897, with a gage height of 2.00 feet, gave a discharge of 251 second-feet; July 2, with a gage height of 2.05 feet, gave a discharge of 240 second-feet; September 3, with a gage height of 1.60 feet, gave a discharge of 122 second-feet; October 12, with a gage height of 1.70 feet, gave a discharge of 120 second-feet.

Daily gage height, in feet, of Antietam Creek at Sharpsburg, Maryland, from July to December, 1897.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	1.90	1.50	1.70	1.50	1.45	1.70	17.....	1.75	1.80	1.60	1.60	1.70	2.20
2.....	2.10	1.70	1.70	1.60	2.70	1.60	18.....	1.70	1.70	1.60	1.40	1.60	2.10
3.....	1.85	1.70	1.60	1.40	2.05	1.60	19.....	1.75	1.60	1.60	1.50	1.50	2.00
4.....	1.70	1.75	1.60	1.60	1.90	1.70	20.....	1.75	1.50	1.50	1.70	1.60	2.10
5.....	1.75	1.60	1.50	1.70	1.60	2.25	21.....	1.85	1.50	1.60	1.70	1.70	2.00
6.....	1.80	1.70	1.70	1.60	1.60	2.45	22.....	1.85	1.55	1.60	1.60	1.60	2.00
7.....	1.70	1.70	1.70	1.70	1.70	2.05	23.....	1.70	1.60	1.70	1.60	1.50	2.10
8.....	1.70	1.50	1.60	1.60	1.75	2.00	24.....	1.70	3.00	1.90	1.65	1.70	2.50
9.....	1.70	1.40	1.65	1.50	1.80	1.80	25.....	1.55	2.90	1.80	1.65	1.80	2.20
10.....	1.70	1.70	1.60	1.40	1.60	1.90	26.....	1.65	2.00	1.50	1.80	1.80	2.00
11.....	1.55	1.90	1.60	1.50	1.55	1.90	27.....	1.75	1.75	1.70	1.70	1.90	2.00
12.....	1.75	1.85	1.50	1.60	1.50	1.90	28.....	1.80	1.70	1.60	1.60	2.00	1.90
13.....	1.95	1.60	1.40	1.70	1.60	2.05	29.....	1.85	1.55	1.60	1.60	1.90	1.80
14.....	1.80	1.70	1.50	1.50	1.40	2.00	30.....	1.80	1.80	1.50	1.60	1.80	1.80
15.....	1.80	2.45	1.60	1.60	1.50	2.35	31.....	1.70	1.70	.....	1.50	.....	1.90
16.....	1.80	1.90	1.70	1.65	1.75	2.40							

PORT REPUBLIC STATION ON NORTH AND SOUTH RIVERS.

This locality is described in the Eighteenth Annual Report of this Survey, Part IV, page 25. The gage for the North River is located on the county highway bridge at Port Republic, Virginia, and 500 feet above the mouth of South River. A painted rod is fastened to the third panel of the first span on the lower side of the bridge. It is nailed to the wooden uprights and fastened by wire to the iron diagonals. The zero of the rod is opposite the middle of the third upright, and is 4.50 feet from the outside edge of the pulley. The distance from the end of the weight to the marker is 31.98 feet. From the top of the lower end of the third floor beam from the right bank to the zero of the gage is 24.97 feet. The bridge seat on lower end of right-bank abutment is 24.60 feet above the datum of gage.

The gage for the South River is located on the county iron bridge, just east of the town, and 300 feet above the mouth of North River. It is a wire gage. The edge of the pulley is 2.54 feet from the north edge of the third vertical. The marks on the gage are made by tacks driven into the rail on the upper side of the bridge at the fourth panel. The zero is 1 foot from the edge of the pulley. The distance from the bottom of the weight to the wire marker or zero point is 26.12 feet. The top of the third floor beam from right bank, upper side of bridge, is 22.52 feet above gage datum. The zero of North River gage is 2.56 feet below the zero of South River gage. The observer is T. S. Davis.

All gagings of South River include discharge of mill race.

The following dicharge measurements were made by D. C. Humphreys and G. H. Matthes during the year 1897:

On North River:
March 23, gage height, 3.54 feet; discharge, 1,466 second-feet.
April 19, gage height, 2.60 feet; discharge, 712 second-feet.
June 1, gage height, 2.60 feet; discharge, 552 second-feet.
July 24, gage height 2 30 feet; discharge, 431 second-feet.
November 7, gage height, 2.00 feet; discharge, 245 second-feet.
On South River:
March 23, gage height, 2.30 feet; discharge, 426 second-feet.
April 19, gage height, 1.88 feet; discharge, 202 second-feet.
June 1, gage height, 1.87 feet; discharge, 182 second-feet.
July 24, gage height, 1.40 feet; discharge, 132 second-feet.
November 7, gage height, 1.80 feet; discharge, 173 second-feet.

Daily gage height, in feet, of North River at Port Republic, Virginia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.35	2.35	3.60	2.70	2.40	2.60	2.35	2.15	2.00	1.80	2.20	1.85
2	2.35	2.35	3.50	2.70	11.50	2.55	2.45	2.15	2.00	1.80	2.00	1.85
3	2.35	2.35	3.40	2.60	7.30	2.50	2.45	2.15	2.00	1.80	2.60	1.85
4	2.35	2.35	3.40	2.60	5.15	2.50	2.40	2.15	2.00	1.80	2.00	1.85
5	2.35	2.35	3.35	2.60	4.30	3.00	2.35	2.15	1.95	1.80	2.00	2.00
6	2.30	2.55	3.30	2.90	3.80	2.85	2.25	2.15	1.95	1.80	2.00	2.00
7	2.30	7.00	3.30	2.90	3.50	2.60	2.20	2.10	1.90	1.80	2.00	1.95
8	2.30	5.50	3.30	2.90	3.30	2.55	2.40	2.10	1.90	1.80	1.95	1.95
9	2.30	4.80	3.25	2.90	3.10	2.50	2.30	2.10	1.90	1.80	1.90	1.90
10	2.30	4.30	3.25	3.00	3.00	2.50	2.20	2.10	1.85	1.80	1.90	1.83
11	2.30	4.00	3.25	3.00	3.00	2.45	2.15	2.05	1.85	1.80	1.90	1.85
12	2.30	3.90	3.25	3.00	3.00	2.40	2.50	2.05	1.85	1.80	1.85	1.85
13	2.30	5.45	3.20	2.90	4.90	2.40	2.40	2.05	1.85	2.00	1.85	1.85
14	2.30	4.70	3.30	2.90	7.50	2.40	2.40	2.05	1.85	2.00	1.80	1.85
15	2.25	5.00	3.50	2.90	5.20	2.40	2.30	2.00	1.85	2.00	1.80	2.65
16	2.25	5.30	3.50	2.90	4.40	2.40	2.20	2.00	1.85	1.95	1.90	2.45
17	2.25	5.20	3.70	2.90	4.00	2.40	2.20	2.00	1.85	1.95	1.90	2.25
18	2.25	4.60	3.70	2.80	3.60	2.40	2.15	2.00	1.85	1.95	1.90	2.10
19	2.25	4.50	3.70	2.65	3.45	2.40	3.50	2.00	1.80	1.95	1.90	2.25
20	2.25	4.30	3.70	2.60	3.25	2.50	3.50	2.00	1.80	1.95	1.90	2.25
21	2.25	4.20	3.90	2.55	3.15	2.45	2.50	.....	1.80	2.00	1.85	2.25
22	2.25	4.80	3.60	2.50	3.10	2.40	2.40	2.00	1.80	2.00	1.85	2.25
23	2.25	9.85	3.35	2.50	3.00	2.40	2.35	2.00	1.80	2.00	1.85	2.25
24	2.25	6.70	3.40	2.50	2.95	2.40	2.35	2.00	1.80	2.00	1.85	2.25
25	2.25	5.40	3.30	2.50	2.90	2.40	2.30	2.00	1.80	2.00	1.85	2.25
26	2.25	4.50	3.20	2.50	2.85	2.40	2.25	2.00	1.80	2.00	1.85	2.25
27	2.25	4.40	3.10	2.45	2.80	2.35	2.20	2.00	1.80	2.00	1.85	2.25
28	2.25	3.80	3.00	2.45	2.75	2.35	2.15	2.00	1.80	2.10	1.85	2.25
29	2.25	.....	2.90	2.45	2.70	2.35	2.15	2.00	1.80	2.05	1.85	2.25
30	2.25	.....	2.80	2.40	2.65	2.35	2.15	2.00	1.80	1.95	1.85	2.20
31	2.35	.....	2.70	.....	2.60	.....	2.15	2.00	.....	1.95	.....	2.15

Daily gage height, in feet, of South River at Port Republic, Virginia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.45	1.85	2.60	2.00	1.75	1.85	1.60	1.50	1.20	1.30	1.75	1.50
2	1.45	1.85	2.50	2.00	9.80	1.80	1.65	1.50	1.20	1.30	2.80	1.50
3	1.45	1.85	2.40	2.00	4.50	1.75	1.65	1.50	1.20	1.30	2.50	1.50
4	1.45	1.85	2.40	2.00	3.30	1.75	1.60	1.50	1.20	1.30	2.10	1.50
5	1.45	1.85	2.35	2.00	3.00	1.90	1.55	1.50	1.20	1.30	2.00	1.50
6	1.45	1.95	2.30	2.10	2.80	1.75	1.55	1.50	1.20	1.30	2.00	1.50
7	1.45	5.00	2.30	2.10	2.50	1.70	1.55	1.50	1.20	1.30	1.80	1.50
8	1.45	4.10	2.30	2.10	2.50	1.65	1.55	1.45	1.20	1.30	1.75	1.50
9	1.45	3.20	2.25	2.10	2.40	1.60	1.55	1.40	1.20	1.30	1.70	1.50
10	1.45	3.05	2.25	2.10	2.30	1.55	1.55	1.40	1.20	1.30	1.70	1.50
11	1.45	2.95	2.25	2.00	2.30	1.50	1.55	1.40	1.20	1.30	1.70	1.50
12	1.45	2.90	2.25	2.00	2.30	1.50	1.55	1.40	1.30	1.30	1.65	1.50
13	1.45	3.15	2.20	1.90	3.20	1.65	1.50	1.40	1.30	1.45	1.65	1.50
14	1.45	3.15	2.30	1.90	4.80	1.65	1.50	1.40	1.30	1.45	1.65	1.50
15	1.45	3.15	2.40	1.90	3.20	1.65	1.50	1.35	1.30	1.45	1.65	1.45
16	1.45	3.40	2.60	1.90	2.85	1.65	1.50	1.35	1.30	1.45	1.65	2.40
17	1.45	3.40	2.60	1.90	2.70	1.60	1.50	1.35	1.30	1.45	1.65	2.00
18	1.45	3.20	2.60	1.85	2.50	1.60	1.50	1.30	1.30	1.45	1.65	1.90
19	1.45	3.20	2.60	1.85	2.40	1.60	1.70	1.25	1.30	1.45	1.65	1.90
20	1.45	3.10	2.60	1.80	2.35	1.65	1.60	1.20	1.30	1.45	1.65	1.85
21	1.45	3.10	2.70	1.80	2.30	1.80	1.55	1.20	1.30	1.50	1.60	1.80
22	1.45	3.60	2.50	1.80	2.25	1.70	1.50	1.20	1.30	1.50	1.55	1.80
23	1.45	6.75	2.30	1.80	2.20	1.65	1.50	1.20	1.30	1.50	1.55	1.80
24	1.65	4.10	2.35	1.80	2.20	1.60	1.50	1.20	1.30	1.50	1.55	1.80
25	1.85	3.30	2.25	1.80	2.20	1.60	1.45	1.20	1.30	1.50	1.50	1.80
26	1.85	3.20	2.15	1.80	2.15	1.60	1.40	1.20	1.30	1.50	1.50	1.80
27	1.85	3.10	2.05	1.80	2.15	1.60	1.40	1.20	1.30	1.50	1.50	1.80
28	1.85	2.80	2.10	1.80	2.10	1.60	1.40	1.20	1.30	2.00	1.50	1.80
29	1.85	.....	2.10	1.80	2.10	1.60	1.40	1.20	1.30	1.90	1.50	1.80
30	1.85	.....	2.10	1.75	2.00	1.60	1.40	1.20	1.30	1.85	1.50	1.80
31	1.85	.....	2.00	.....	1.95	.....	1.40	1.20	.....	1.75	.....	1.80

MILLVILLE STATION ON SHENANDOAH RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 26, is located at a point 4 miles above Harpers Ferry, at Millville, West Virginia. A vertical gage was placed in the river and secured to the trunk of a tree. A deep notch was cut in the tree opposite the 8-foot mark. Bench mark 2 is a copper bolt driven into an auger hole in the foot of a large sycamore (buttonwood) tree on the left bank of the river, about 150 feet below the gage rod, and it is 6.78 feet above the zero mark on the gage. A new three-fourths inch galvanized steel wire cable was stretched across the river on June 23, 1897, the old one having been carried out by the flood of October 1, 1896. The cable, which is about 500 feet long, is supported on either bank by a large sycamore tree, and is securely anchored on both sides. The observer is H. C. Nisewaner. The following discharge measurements were made by E. G. Paul and others, in 1897:

June 24, gage height, 1.20 feet; discharge, 1,371 second-feet.
July 23, gage height, 1.80 feet; discharge, 2,791 second-feet.
September 7, gage height, 0.50 foot; discharge, 632 second-feet.
October 25, gage height, 0.70 foot; discharge, 814 second feet.

Daily gage height, in feet, of Shenandoah River at Millville, West Virginia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.60	1.10	3.70	2.00	1.40	1.50	1.00	1.00	0.60	0.40	0.80	0.70
2	1.50	1.10	3.50	2.00	1.70	1.50	.90	.90	.60	.40	.80	.70
3	1.40	1.60	3.50	1.90	9.25	1.40	.90	.80	.60	.40	.80	.60
4	1.40	2.00	3.50	1.90	7.10	1.60	.90	.80	.50	.40	1.00	.70
5	1.30	2.20	3.50	2.10	5.10	1.60	1.00	.80	.50	.40	1.30	.90
6	1.30	2.20	3.50	2.30	4.60	1.90	.90	1.40	.50	.40	1.00	1.70
7	1.30	(a)	3.40	2.30	3.60	1.80	.80	.90	.50	.35	.80	1.20
8	1.20	(a)	3.30	2.40	3.20	1.70	.80	.90	.50	.35	.80	1.10
9	1.20	(a)	3.00	2.40	2.90	1.60	.80	.90	.50	.35	.70	.90
10	1.10	6.00	2.80	2.40	2.50	1.60	.80	.80	.40	.35	.80	.90
11	1.10	5.30	2.70	2.40	2.40	1.40	.....	1.20	.40	.40	.70	.80
12	1.10	4.70	2.60	2.40	2.40	1.40	1.10	1.00	.40	.50	.70	.90
13	1.40	4.00	2.60	2.30	2.50	1.40	1.00	.90	.40	.50	.50	.90
14	1.40	6.00	2.80	2.30	4.35	1.30	1.00	.80	.40	.50	.50	1.00
15	1.30	4.70	2.80	2.30	6.60	1.30	1.20	.70	.40	.50	.70	1.70
16	1.20	5.75	3.50	2.20	4.90	1.30	.90	.70	.40	.50	.65	2.40
17	1.10	5.90	3.60	2.20	3.90	1.30	.90	.70	.40	.50	.70	2.70
18	1.10	5.30	3.40	2.10	3.50	1.20	.90	.70	.40	.45	.60	2.20
19	1.10	4.90	3.20	2.10	3.20	1.20	.80	.60	.40	.40	.60	1.80
20	1.10	4.60	3.20	2.00	2.90	1.60	1.90	.60	.40	.40	.50	1.60
21	1.10	4.50	3.60	1.90	2.60	1.60	2.60	.60	.40	.45	.60	1.30
22	1.20	6.45	3.40	1.80	2.40	1.40	2.60	.60	.40	.50	.60	1.30
23	1.20	10.05	3.30	1.80	2.30	1.30	1.80	.60	.40	.50	.60	1.30
24	1.20	10.05	3.20	1.70	2.20	1.20	1.50	1.00	.60	.55	.55	1.30
25	1.10	6.70	3.00	1.70	2.20	1.10	1.30	1.30	1.20	.70	.50	1.30
26	1.10	5.50	2.90	1.60	2.20	1.10	1.20	1.00	.50	.80	.50	2.00
27	1.10	4.60	2.70	1.50	1.80	1.10	1.10	.90	.50	.90	.80	1.50
28	1.10	4.60	2.50	1.50	1.60	1.00	1.20	.80	.50	.80	.90	1.60
29	1.10	.....	2.40	1.40	1.60	1.00	1.50	.70	.40	.80	.70	1.50
30	1.10	.....	2.10	1.40	1.60	.90	1.30	.70	.40	.80	.60	1.20
31	1.00	.....	2.00	.....	1.60	.....	1.10	.80	.....	.90	.....	1.10

a Gage washed out.

FREDERICK STATION ON MONOCACY RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 34, is at the county iron bridge on the turnpike 4 miles northeast of Frederick, on the road leading from Frederick to Mount Pleasant, Maryland. A wire gage is attached to the floor timber on the lower side of the bridge. The length of the gage wire from bottom of weight to end of handle is 35.20 feet.

The bench mark is a cross cut in the top face of a capstone on the lower retaining wall of the bridge abutment on the right bank of the stream. It is 24.97 feet above the surface of the water when the gage reads 4.2 feet. The observer is E. L. Derr. The stream at this station has two channels, being divided by a small, low island, which serves as a foundation for the middle pier of the bridge.

On January 26, 1898, the gage was compared with the bench mark, and the wire found to have stretched 0.37 foot. The gage wire was corrected and the gage heights of the preceding months reduced by this amount, those in July and August, when the stretching is supposed to have occurred, being approximated only. The following discharge measurements were made by E. G. Paul and others during the year 1897:

February 9, gage height, 6.00 feet; discharge, 1,019 second-feet.
February 24, gage height, 8.95 feet; discharge, 3,569 second-feet.
March 9, gage height, 6.00 feet; discharge, 1,085 second-feet.
April 10, gage height, 7.55 feet; discharge, 2,264 second-feet.
July 3, gage height, 4.30 feet; discharge, 220 second-feet.
September 3, gage height, 4.15 feet; discharge, 182 second-feet.

Daily gage height, in feet, of Monocacy River at Frederick, Maryland, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.[a]	Aug.[a]	Sept.	Oct.	Nov.	Dec.
1	4.20	4.40	5.70	5.00	4.60	5.00	4.20	4.90	4.15	3.95	4.15	5.25
2	4.20	4.40	5.50	5.00	6.30	4.80	4.20	4.70	4.05	3.95	14.85	5.15
3	4.20	5.00	5.60	4.90	6.20	4.70	4.30	4.50	4.15	3.85	8.15	5.15
4	4.20	6.00	7.50	4.90	6.20	5.00	4.20	4.40	4.05	3.85	6.55	8.15
5	4.20	5.50	7.50	6.90	6.00	7.50	4.20	4.40	4.05	3.75	5.35	12.40
6	4.30	8.40	8.00	5.90	5.90	5.60	4.20	4.30	3.95	3.85	5.05	8.65
7	4.30	15.00	7.60	5.60	5.60	5.40	4.20	4.30	3.95	3.75	4.85	7.20
8	4.50	8.45	6.20	5.40	5.40	4.95	4.20	4.20	3.95	3.75	4.75	6.55
9	4.40	6.00	6.00	9.30	5.10	6.15	4.90	4.20	3.95	3.75	5.55	5.95
10	4.30	5.60	6.50	8.55	5.00	5.80	4.50	4.20	3.95	3.85	5.55	5.75
11	4.20	5.20	6.20	6.55	5.10	5.30	4.20	10.60	3.95	3.85	4.85	5.55
12	4.30	5.20	5.80	6.60	5.10	5.00	4.20	8.50	3.95	3.85	4.75	6.85
13	4.30	4.90	5.80	5.70	15.60	4.90	7.00	5.45	3.95	4.25	4.65	6.65
14	4.30	4.60	5.70	5.80	15.60	4.70	5.20	4.45	3.85	4.15	4.55	11.65
15	4.00	4.60	5.70	5.90	10.90	4.70	4.60	4.25	3.85	4.05	5.15	14.95
16	4.00	5.70	5.80	6.20	7.40	4.70	4.30	5.35	3.85	3.95	5.55	13.85
17	4.00	7.40	5.40	5.80	6.80	4.80	4.30	4.85	4.45	3.95	4.95	7.15
18	4.00	7.40	6.60	5.80	6.50	4.80	5.10	4.30	4.45	3.85	4.75	6.65
19	4.30	6.70	7.00	5.50	6.10	4.70	4.95	4.10	4.05	3.75	4.65	6.15
20	4.70	6.10	9.80	5.30	5.80	4.70	5.25	4.10	3.85	3.75	4.55	5.95
21	4.50	5.70	7.80	5.10	5.90	4.90	4.95	4.10	3.85	3.85	4.65	5.85
22	5.50	12.13	6.60	5.00	6.00	4.70	6.40	5.50	3.95	3.95	4.55	6.55
23	5.40	14.60	6.50	5.00	5.50	4.50	5.65	4.80	3.95	3.95	4.75	6.05
24	4.80	8.85	7.40	5.00	5.30	4.50	4.95	16.20	5.65	3.95	5.60	5.65
25	5.20	8.30	7.30	4.90	6.70	4.40	4.45	6.75	5.15	4.05	4.85	5.15
26	5.00	7.00	6.10	4.90	6.00	4.40	4.35	5.75	4.65	4.35	6.55	5.55
27	5.00	6.50	5.80	4.90	5.30	4.40	7.70	5.10	3.95	4.25	7.05	5.45
28	5.00	6.00	5.60	4.80	5.20	4.40	9.90	4.70	3.95	4.15	6.55	5.45
29	5.00	.....	5.40	4.70	5.00	4.20	7.80	4.25	3.95	4.05	5.85	5.25
30	4.80	.....	5.30	4.60	4.90	4.20	6.10	4.15	3.95	4.05	5.65	5.25
31	4.50	.....	5.20	.....	5.00	.....	5.30	4.15	.....	3.95	.....	5.45

[a] Approximate.

POINT OF ROCKS STATION ON POTOMAC RIVER.

This station, described in the Eighteenth Annual Report of this Survey, Part IV, page 29, is about 6 miles above the mouth of Monocacy River, at Point of Rocks, Maryland. At this point a toll bridge crosses the stream 1,000 feet below the mouth of Catoctin Creek. A wire gage has been established on the east side of the first span; the scale is marked with nails on the hand rail. Bench mark 1 is a copper bolt fastened in a hole drilled in a large capstone on the lower wing wall of the north abutment, a short distance from the north end of the first iron truss, and is 41.30 feet above the datum of the gage. Bench mark 2, top of second floor beam from left bank, lower end, is 39.28 feet above datum. The distance from the end of the weight to the wire index is 44.22 feet. On January 25, 1898, a comparison with the bench mark revealed that the gage wire had stretched 1.78 feet. A new wire was substituted and the gage heights of the preceding months were reduced to the correct datum; those in August and September, when the stretching is supposed to have occurred, being approximated only. The observer is G. H. Hickman. During the year 1897 discharge measurements were made by E. G. Paul and G. H. Matthes, as follows:

February 9, gage height, 7.95 feet: discharge, 40,654 second-feet.
February 23, gage height, 21.70 feet; discharge, 169,913 second-feet.
March 8, gage height, 5.70 feet; discharge, 27,383 second-feet.
March 27, gage height, 4.05 feet; discharge, 17,121 second-feet.
July 23, gage height, 2.85 feet; discharge, 8,130 second-feet.
October 29, gage height, 0.20 foot; discharge, 2,141 second-feet.

Daily gage height, in feet, of Potomac River at Point of Rocks, Maryland, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.[a]	Sept.[a]	Oct.	Nov.	Dec.
1	0.80	2.00	5.30	2.80	2.20	2.50	1.80	1.80	0.30	0.00	0.20	0.90
2	.80	1.90	4.40	2.70	2.40	2.40	1.70	1.70	.20	.00	.30	.90
3	.80	2.50	4.20	2.60	7.00	2.30	1.80	1.50	.20	.00	1.00	.90
4	.90	2.00	4.10	2.60	14.50	2.40	1.80	1.40	.20	.00	1 40	1.00
5	.90	2.10	4.60	2.70	9.00	2.50	1.70	1.30	.20	.00	1.00	1.10
6	1.00	5.10	4.40	3.00	6.50	2.50	1.70	1.70	.20	— .10	.80	3.20
7	1.40	8.00	6.00	3.30	5.90	2.40	1.70	1.20	.20	— .10	.70	3.60
8	1.70	10.50	5.80	3.50	5.10	2.50	1.70	1.10	.10	— .10	.50	3.20
9	1.50	7.90	5.00	3.40	4.50	2.50	1.60	1.10	.00	— .10	.50	2.40
10	1.30	5.80	4.50	4.20	4.00	2.30	1.50	1.10	.00	— .10	.50	1.50
11	1.10	4.60	4.20	6.20	3.70	2.20	1.90	1.10	— .10	.00	.70	1.30
12	1.10	4.00	4 00	5.10	3.50	2.20	1.80	1.00	— .10	.10	1.20	1.10
13	1.10	3.90	3.90	4.40	3.80	2.10	1.80	1.00	— .10	— .10	.80	1.00
14	.90	4.60	3.70	4.00	9.40	2.10	1.90	.80	— .10	.00	.50	.90
15	.90	5.70	3.70	3.80	13.10	2.20	1.90	.80	— .10	.00	.50	1.50
16	1.00	7.00	3.80	3.60	8.50	2.20	2.00	.80	— .10	— .10	.60	4.10
17	.90	7.40	4.20	3.50	5.50	2.10	1.80	.60	— .10	— .10	1.10	4.30
18	.90	7.70	4.40	3.40	4.90	2.10	1.60	.50	— .10	— .10	.90	3.30
19	.90	7.60	4.70	3.30	4.60	2.20	1.90	.40	— .10	— .10	.70	2.60
20	1.50	7.20	5.30	3.10	4.40	2.20	1.90	.30	— .10	— .10	.70	2.20
21	1.50	6.40	6.20	3.00	4.00	2.60	2.60	.30	— .10	— .10	.60	2.10
22	1.40	6.70	6.00	2.80	3.70	2.50	3.10	.30	— .10	.00	.60	1.60
23	1.40	21.15	5.55	2.70	3.40	2.30	3.20	.30	.00	— .10	.60	1.50
24	1.40	24.60	4.80	2.60	3.30	2.20	2.60	.30	.20	— .10	.40	1.40
25	1.50	16.10	4.70	2.60	3.40	2.10	2.40	.90	.00	.00	.40	1.30
26	1.80	9.30	4.60	2.50	3.50	2.10	2.40	.80	.00	.00	.40	1.30
27	2.00	7.30	4.10	2.40	3.30	2.10	2.60	.40	.00	.00	1.00	1.20
28	2.30	6.00	3.80	2.40	3.00	2.00	2.70	.40	.00	.10	.60	1.20
29	2.20	.....	3.60	2.30	2.70	1.90	2.60	.40	.00	.20	.50	1.10
30	2.10	.....	3.30	2.20	2.60	1.80	2.40	.40	.00	.20	.60	1.10
31	2.00	.....	2.90	.....	2.50	.....	2.30	.40	.....	.20	.....	1.10

[a] Approximate.

PARK STATION ON ROCK CREEK.

A station was established on Rock Creek January 18, 1897, at the Park bridge, near the eastern entrance of the National Zoological Park, in the city of Washington, District of Columbia. The upper part of the gage is vertical and is fastened to the bridge abutment, the lower portion being inclined and fastened to iron rods. The bench mark consists of an X on the stone of the bridge pier. It is 9.13 feet above the zero of the gage. The observer is W. V. Kramer, one of the watchmen in the park. A measurement on August 18, 1897, at a gage height of 2.90 feet gave a discharge of 26 second-feet, and on November 21, at a gage height of 3.00 feet a discharge of 37 second-feet.

A study of the discharge of Rock Creek was begun in July, 1892, at the request of the Commissioners of the District of Columbia. In July, 1892, a gage rod was established by Cyrus C. Babb at Lyon's Mill, and fastened to the downstream face of the right abutment of the bridge. On August 18, 1892, a self-registering gage was placed at the bridge, and the record continued until November 30, 1894.

The following are the discharge measurements made at this point:

July 28, 1892, gage height, 0.00 foot; discharge, 89 second-feet.
August 2, 1892, gage height, —0.30 foot; discharge, 49 second-feet.
August 3, 1892, gage height, —0.3 foot; discharge, 48 second-feet.
August 5, 1892, gage height, 0.19 foot; discharge, 102 second-feet.
April 11, 1893, gage height, —0.12 foot; discharge, 58 second-feet.
May 4, 1893, gage height, 4.14 feet; discharge, 959 second-feet.

Daily gage height, in feet, of Rock Creek at Zoological Park Bridge, District of Columbia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.90	2.35	2.30	2.30	2.30	3.10	3.05	2.85	2.80	3.10	3.05
2	.....	3.50	2.35	2.25	2.40	2.50	3.10	3.00	2.85	2.85	3.50	3.05
3	.....	4.15	2.35	2.25	2.45	2.65	3.10	3.00	2.85	2.85	3.30	3.05
4	.....	3.45	2.40	2.25	2.55	2.95	3.05	2.95	2.85	2.85	3.10	3.25
5	.....	3.15	2.35	2.50	2.50	3.15	3.05	2.95	2.85	2.85	3.05	3.90
6	.....	3.25	2.35	2.65	2.35	3.10	3.05	3.00	2.85	2.85	3.00	3.35
7	.....	4.25	2.40	2.45	2.30	3.25	3.05	2.95	2.80	2.85	2.95	3.20
8	.....	2.70	2.35	2.40	2.20	3.40	3.60	2.95	2.80	2.85	3.00	3.15
9	.....	2.50	2.35	3.15	2.20	3.45	3.15	2.95	2.80	2.85	3.20	3.10
10	.....	2.40	2.35	2.90	2.15	3.40	3.10	2.95	2.80	2.85	3.35	3.10
11	.....	2.30	2.30	2.60	2.20	3.40	3.10	3.00	2.80	2.85	3.10	3.10
12	.....	2.45	2.30	2.50	2.50	3.35	3.25	3.00	2.80	3.15	3.05	3.10
13	.....	2.60	2.35	2.45	3.70	3.35	3.30	2.95	2.80	2.85	3.05	3.10
14	.....	2.60	2.45	2.45	2.65	3.35	3.30	2.90	2.80	2.85	3.00	3.25
15	.....	2.65	2.60	2.40	2.95	3.35	3.10	2.90	2.80	2.85	3.05	4.30
16	.....	2.45	2.40	2.45	2.60	3.35	3.00	2.95	2.80	2.85	3.10	3.35
17	.....	2.40	2.35	2.45	2.50	3.35	3.10	3.00	2.80	2.85	3.05	3.20
18	3.00	2.30	2.95	2.40	2.40	3.35	2.10	2.90	2.90	2.90	3.05	3.15
19	2.95	2.30	2.85	2.35	2.40	3.20	3.45	2.90	2.85	2.90	3.05	3.10
20	2.90	2.25	3.05	2.30	2.35	3.30	3.25	2.90	2.80	3.00	3.05	3.10
21	3.15	2.40	2.90	2.30	2.30	3.25	3.25	2.90	2.80	3.00	3.00	3.15
22	3.30	3.75	2.65	2.30	2.30	3.15	4.00	2.90	2.80	2.95	3.00	3.20
23	3.35	4.10	2.55	2.30	2.25	3.15	3.40	2.90	2.90	2.95	3.05	3.20
24	3.05	2.85	2.50	2.30	2.60	3.15	3.10	2.95	3.20	3.00	3.05	3.30
25	2.90	2.60	2.55	2.30	3.45	3.25	3.05	2.90	2.90	3.10	3.00	3.05
26	3.00	2.50	2.40	2.25	2.55	3.15	3.00	2.90	2.80	3.10	3.05	3.10
27	2.90	2.45	2.40	2.25	2.40	3.10	3.45	2.90	2.80	3.00	3.95	3.10
28	2.90	2.45	2.35	2.20	2.35	3.10	4.30	2.85	2.80	2.95	3.30	3.05
29	2.95	.....	2.30	2.25	2.30	3.10	3.10	2.85	2.80	2.90	3.15	3.00
30	2.90	.....	2.30	2.25	2.30	3.10	3.10	2.85	2.80	2.90	3.10	3.10
31	2.90	.....	2.30	.....	2.25	.....	3.10	2.85	.....	2.90	.....	3.10

GLASGOW STATION ON NORTH RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 36, is at the Glasgow, Virginia, county bridge about 1 mile above the mouth of North River. The height of water is observed by means of a wire gage, the board being placed on the guard rail on the lower side of the bridge and graduated in feet and tenths. The distance from the top of the bridge over the gage to the zero is 32.24 feet, and that from the end of the weight to the marker of the gage is 27.86 feet. The observer is B. G. Baldwin. Discharge measurements are made at the bridge. The initial point for sounding is on the left bank. The channel is straight for about 200 feet above and below the station, but farther downstream it is curved, and the water moves with moderate velocity. The stream is confined within its channel by the bridge abutments, except at very high water, when it may overflow the left bank. The bed is composed of rock and gravel and is fairly permanent. The following discharge measurements were made by Prof. D. C. Humphreys and F. H. Anschutz during 1897:

May 29, gage height, 1.91 feet; discharge, 546 second-feet.
August 14, gage height, 1.17 feet; discharge, 208 second-feet.
October 14, gage height, 1.30 feet; discharge, 223 second-feet.

Daily gage height, in feet, of North River at Glasgow, Virginia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.52	1.70	2.85	2.22	1.78	1.85	1.35	.....	1.17	1.08	1.40	1.40
2	1.51	1.74	2.68	2.21	5.80	1.78	2.65	1.20	1.14	1.05	1.65	1.42
3	.....	1.76	2.58	2.22	4.70	1.75	1.95	1.20	1.10	1.05	1.60	1.38
4	1.55	1.80	2.50	2.27	3.52	1.75	1.88	1.14	1.10	1.02	1.50	1.41
5	1.60	1.92	2.46	2.38	3.05	1.85	1.80	1.52	1.08	1.02	1.41	1.60
6	1.75	4.70	2.40	2.58	2.76	.....	1.73	1.32	1.05	1.03	1.30	1.80
7	1.65	6.05	2.40	2.55	2.58	1.87	1.66	1.25	1.08	1.03	1.20	1.75
8	1.60	4.86	2.42	2.50	2.40	1.85	1.60	1.18	1.07	1.02	1.41	1.68
9	1.65	4.50	2.40	2.52	.....	1.80	1.52	1.18	1.05	1.02	1.25	1.60
10	1.65	3.62	2.48	2.62	2.20	1.75	1.45	1.15	1.00	1.00	1.23	1.52
11	1.60	3.51	2.48	.....	2.20	1.70	1.38	1.18	1.00	1.10	1.20	1.50
12	1.60	3.32	2.58	2.52	2.22	1.63	1.30	1.15	.....	1.20	1.18	1.45
13	1.58	4.40	3.00	2.38	4.70	.....	1.25	1.12	1.05	1.18	1.18	1.45
14	1.58	4.05	.....	2.30	7.30	1.65	1.20	1.17	1.10	1.15	1.18	1.56
15	1.55	3.81	4.26	2.27	4.42	1.72	1.20	.....	1.08	1.20	1.20	2.62
16	1.52	4.00	3.70	2.25	.....	1.66	1.18	1.20	1.10	1.18	1.18	2.65
17	1.53	3.90	3.27	2.14	3.20	1.67	1.12	1.20	1.08	1.20	1.20	2.15
18	1.55	3.50	3.33	2.08	2.93	1.66	1.40	1.16	1.10	1.18	1.15	2.00
19	1.55	3.40	.....	2.00	2.77	1.65	1.30	1.10	1.10	1.20	1.21	1.85
20	1.52	3.40	3.72	2.00	2.56	.....	1.30	1.10	1.05	1.20	1.15	1.70
21	1.70	.....	3.46	1.90	2.50	1.90	1.35	1.08	1.08	1.20	1.16	1.65
22	1.90	5.10	3.20	1.88	2.35	1.70	1.70	.....	1.10	1.25	1.15	1.80
23	2.02	7.72	3.00	1.88	.....	1.62	(a)	1.14	1.10	1.20	1.15	1.75
24	1.98	5.35	3.00	1.87	2.23	1.60	(a)	1.40	1.12	1.18	1.20	1.70
25	1.90	4.75	2.90	1.86	2.20	1.60	(a)	1.30	1.11	1.20	1.12	1.68
26	1.85	3.36	2.70	1.86	2.10	1.50	1.25	1.30	1.10	1.20	1.15	1.75
27	1.75	3.15	2.60	1.80	2.02	1.45	1.25	1.42	1.10	1.18	1.20	1.80
28	1.70	2.95	2.54	1.75	2.00	1.40	1.26	1.27	1.09	1.22	1.20	1.80
29	1.60	.....	2.42	1.75	1.95	1.40	1.23	.....	1.10	1.15	1.40	1.75
30	1.60	.....	2.31	1.75	.....	1.38	1.23	1.20	1.10	1.25	1.42	1.68
31	1.65	.....	2.30	.....	1.90	.....	1.24	1.18	.....	1.28	.....	1.60

a Gage broken.

July 4–14 interpolated by D. C. Humphreys.

BUCHANAN STATION ON JAMES RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 39, is on James River, about 20 miles above the mouth of North River and one-half mile above the mouth of Purgatory Creek, at the new iron bridge at Buchanan, Virginia. The gage is of wire, and the scale is painted in feet and tenths. The bench mark at this point is the top of a stone post under the southwest corner of the porch of the Chesapeake and Ohio passenger station; the elevation of the bench mark is 24.68 feet above the zero of the gage. The highest point on a prominent ledge of rock on the left bank, about 500 feet above the bridge, is 17.48 feet above the zero of the gage. On April 3, 1897, the zero of this gage was lowered 2 feet to avoid negative readings. The published gage readings for 1897 are referred to this new gage. A new iron bridge was erected at this point in November, and future discharge measurements will be made at this bridge, on which the gage is located. Discharge measurements were made at a bridge three-fourths of a mile above, as the old covered bridge was not suited to the purpose. The initial point was taken on the right bank; the channel is nearly straight both above and below, and the bed of the stream is mostly solid rock and is subject to but little change. The following measurements were made by D. C. Humphreys and others during 1897:

April 1, gage height, 3.30 feet; discharge, 2,007 second-feet.
May 30, gage height, 2.70 feet; discharge, 994 second-feet.
October 13, gage height, 1.70 feet; discharge, 578 second-feet.

Daily gage height, in feet, of James River at Buchanan, Virginia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.10	2.70	4.25	3.30	2.60	2.50	2.10	2.20	1.80	1.30	1.60	1.70
2	2.10	2.80	4.10	3.30	6.40	2.50	2.20	2.10	1.80	1.30	1.80	1.80
3	2.10	2.90	3.85	3.00	7.75	2.50	3.05	2.00	1.70	1.30	1.80	1.90
4	2.10	2.90	3.70	3.00	5.85	3.00	2.70	2.00	1.70	1.30	1.80	2.10
5	2.10	2.90	3.60	3.15	5.20	2.65	2.45	2.40	1.70	1.30	1.70	2.20
6	2.10	8.00	3.50	4.15	5.15	2.50	2.30	2.10	1.70	1.30	1.70	2.20
7	2.10	12.15	3.50	4.00	4.85	2.50	2.30	2.00	1.70	1.30	1.60	2.20
8	2.10	8.80	3.75	3.75	4.60	2.50	2.50	2.00	1.60	1.30	1.60	2.20
9	2.10	7.25	3.70	3.60	4.15	2.50	2.45	2.00	1.60	1.30	1.60	2.20
10	2.10	6.75	3.70	4.10	3.95	2.40	2.30	1.90	1.60	1.30	1.60	2.20
11	2.10	6.10	4.45	4.20	3.85	2.40	2.20	1.90	1.60	1.30	1.60	2.20
12	2.10	5.80	4.90	3.95	3.35	2.35	2.20	1.90	1.60	1.75	1.50	2.20
13	2.10	8.15	6.25	3.70	6.15	2.30	2.20	1.90	1.60	1.75	1.50	2.20
14	2.10	6.50	5.85	3.60	10.45	2.30	2.20	1.90	1.60	1.70	1.40	2.20
15	2.10	6.20	7.90	3.60	7.30	2.40	2.20	1.90	1.60	1.70	1.35	2.55
16	2.10	6.25	6.45	3.50	5.90	2.40	2.20	1.80	1.60	1.70	1.30	2.85
17	2.10	6.50	5.60	3.35	5.00	2.40	2.20	1.80	1.50	1.70	1.30	2.90
18	2.10	5.55	5.10	3.20	4.55	2.40	2.10	1.80	1.50	1.60	1.30	2.70
19	2.10	5.30	6.00	3.10	4.10	2.40	2.20	1.80	1.50	1.60	1.30	2.70
20	2.10	5.30	6.75	3.00	3.80	3.10	2.20	1.80	1.50	1.50	1.30	2.70
21	2.30	6.05	6.35	3.00	3.55	2.50	2.30	1.80	1.50	1.50	1.30	2.70
22	2.30	11.50	5.65	2.90	3.35	2.50	3.35	1.80	1.50	1.50	1.30	2.70
23	2.30	14.00	5.00	2.80	3.15	2.50	3.30	1.80	1.55	1.70	1.30	2.60
24	2.70	11.65	4.65	2.80	3.15	2.40	3.05	2.25	1.90	1.70	1.30	2.85
25	2.90	7.50	4.45	2.70	3.20	2.30	3.05	2.10	1.60	1.70	1.30	2.90
26	2.80	6.10	4.15	2.70	3.10	2.20	2.75	2.00	1.50	1.70	1.30	2.90
27	2.60	5.35	3.95	2.70	3.00	2.40	2.55	2.00	1.50	1.70	1.30	2.90
28	2.90	4.75	3.80	2.60	2.90	2.30	2.50	1.90	1.50	1.60	1.30	2.85
29	2.90	.....	3.65	2.60	2.75	2.20	2.45	1.90	1.40	1.60	1.40	2.70
30	2.90	.....	3.50	2.60	2.70	2.10	2.40	1.90	1.40	1.60	1.50	2.60
31	2.70	.....	3.40	.....	2.55	.....	2.30	1.80	.....	1.60	.....	2.60

ROANOKE STATION ON ROANOKE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 42, is located in the edge of the town of Roanoke, Virginia., at the Walnut-street bridge. The gage is of wire, and the scale is painted in feet and tenths on a horizontal rod fastened to the floor of the bridge. The distance from the end of weight to marker is 24.39 feet. The top of lower end of first floor beam is 21.99 feet above datum of gage. The right bank is above high water, but the left may overflow at extreme high water. The channel is nearly straight and the current good. The observer is A. B. Rawn. A discharge measurement was made on April 2, 1897, by F. H. Anschutz, when the water stood at a height of 1.52 feet, giving a discharge of 320 second-feet.

Daily gage height, in feet, of Roanoke River at Roanoke, Virginia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.75	0.45	1.75	1.55	1.55	1.30	0.70	0.75	0.75	1.50	0.85	0.50
2	.70	.45	1.55	1.55	4.00	1.30	.70	.75	.70	1.45	.85	.50
3	.70	.45	1.20	1.50	3.85	1.75	.75	.80	.65	1.40	.80	.50
4	.65	.45	1.00	1.85	3.45	1.70	.72	.80	.65	1.30	.80	.90
5	.68	.50	.95	1.80	2.95	1.65	.72	1.75	.65	1.25	.80	1.30
6	.60	6.82	.90	1.75	2.75	1.60	.72	1.70	.65	1.20	.75	1.15
7	.55	3.78	1.85	1.70	2.60	1.55	.72	1.65	.65	1.10	.75	1.10
8	.50	2.60	1.25	1.65	2.50	1.55	.70	1.40	.60	1.00	.75	1.00
9	.45	2.20	1.00	1.60	2.25	1.50	.70	1.20	.60	.90	.75	.95
10	.45	1.95	.95	1.55	1.90	1.50	.65	1.00	.60	.90	.70	.95
11	.45	1.90	.90	1.50	1.60	1.50	.62	.80	.55	.85	.70	.90
12	.45	3.00	1.95	1.50	1.58	1.45	1.00	.75	.45	.85	.65	.85
13	.45	2.90	2.20	1.50	1.55	1.45	1.00	.75	.45	1.90	.60	.85
14	.45	2.50	3.60	1.50	1.55	1.40	.95	.75	.45	1.95	.60	.80
15	.50	2.20	3.85	1.50	1.75	1.45	.90	.70	.40	1.85	.60	.80
16	.60	2.00	3.30	1.60	1.70	1.40	.85	.70	.40	1.70	.60	.80
17	.65	1.95	3.00	1.55	1.65	1.40	1.00	.70	.40	1.45	.60	.80
18	.60	1.80	3.00	1.50	1.60	1.35	1.10	.70	.35	1.20	.60	.80
19	.60	1.55	2.90	1.45	1.55	1.75	1.00	.70	.35	1.00	.60	.85
20	.65	1.45	2.75	1.45	1.55	1.75	1.10	.65	.35	1.20	.55	.85
21	.68	4.50	2.60	1.40	1.55	1.70	1.55	.65	.35	1.10	.55	.90
22	.70	4.40	2.45	1.40	1.50	1.65	1.45	.65	.35	1.00	.55	.90
23	.70	8.30	2.10	1.40	1.50	1.60	1.95	.90	1.85	.90	.55	.90
24	.65	3.50	1.95	1.40	1.50	1.55	1.85	1.10	1.85	.90	.55	.95
25	.65	2.60	1.75	1.40	1.45	1.50	1.70	.....	1.75	.85	.50	.95
26	.60	2.20	1.45	1.35	1.45	1.40	1.55	.....	1.70	1.10	.50	.95
27	.50	1.90	1.25	1.30	1.40	1.00	1.40	.....	1.65	1.10	.50	.95
28	.50	1.85	1.65	1.30	1.40	.72	1.25	.....	1.60	1.00	.50	1.00
29	.50	.....	1.63	1.25	1.40	.72	1.00	.75	1.55	.95	.50	1.00
30	.50	.....	1.60	1.20	1.35	.72	.80	.75	1.55	.90	.50	1.10
31	.45	.....	1.58	.....	1.35	.....	.75	.80	.....	.85	.....	1.10

CLARKSVILLE STATION ON DAN AND STAUNTON RIVERS.

This station, described in the Eighteenth Annual Report, Part IV, page 42, is a short distance above the junction of the Dan and Staunton rivers, which unite to form the Roanoke River. On Dan River the rod is fastened to the inside of the guard rail of the fourth panel of the third span west of the Southern Railroad bridge. The distance from the zero of the rod to the outside of the pulley wheel is 3 feet; the length of the wire rope is 33.17 feet. The water power from Dan River has been developed to a considerable extent at Danville. An examination at points above showed that the dams at Danville pond the water, and as a result modify the natural characteristics of the stream. The gage on Staunton River is fastened to the inside of the guard rail of the fourth panel of the third span from the west. The distance from the zero to the outside of the pulley wheel is 3 feet; the length of the wire gage is 33.0 feet; the distance of the water surface below the top and upper end of the third-floor beam of the second span from the west was 27.15 feet when the gage height was 0.25 foot. The distance from the east abutment of the Dan River bridge to the west abutment of the Staunton River bridge is 165 feet. The observer is Lucius Wootton. About 4 miles above the junction of the Dan and Staunton rivers is a cut-off, apparently occupying an old channel, diverting water from the Dan to the Staunton. This cut-off, by carrying water from the Dan, vitiates the separate computations of discharge made at the stations below, but does not affect the total discharge for the Roanoke. The following measurements were made during 1897 by E. W. Myers:

On Dan River:
February 25, gage height, 12.33 feet; discharge, 26,015 second-feet.
March 18, gage height, 4.20 feet; discharge, 7,755 second-feet.
September 29, gage height, 0.10 foot; discharge, 856 second-feet.
On Staunton River:
February 25, gage height, 11.95 feet; discharge, 29,259 second-feet.
March 18, gage height, 3.67 feet; discharge, 8,326 second-feet.
September 29, gage height, —0.25 foot; discharge, 763 second-feet.

Daily gage height, in feet, of Dan River at Clarksville, Virginia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.75	2.70	2.90	1.98	1.72	1.60	1.10	0.71	0.23	0.05	1.55	2.75
2	1.75	3.20	2.75	1.95	2.85	1.56	1.03	.67	.20	.05	1.92	2.35
3	1.74	4.05	2.67	2.00	5.30	1.55	.98	.55	.15	.03	2.45	2.05
4	1.74	2.70	2.35	2.15	4.80	1.63	.95	.48	.15	.01	2.05	1.90
5	1.75	1.85	3.55	2.35	3.25	1.70	.90	.42	.00	— .03	1.60	1.85
6	1.77	2.35	4.65	2.85	3.10	1.08	.87	.38	.00	— .05	1.20	1.65
7	1.75	6.35	4.75	3.15	3.70	1.06	.83	.35	.00	— .09	.98	1.40
8	1.71	12.29	4.60	3.45	3.45	1.04	.98	.35	.00	— .15	.85	1.18
9	1.68	9.20	4.47	3.25	3.05	1.04	.90	.37	.00	— .02	.68	1.05
10	1.65	4.75	3.98	4.10	2.75	1.03	.85	.73	.00	+ .05	.55	.83
11	1.62	3.15	4.03	3.72	3.25	1.02	.80	.79	.00	.05	.42	.70
12	1.60	2.70	4.78	3.45	3.95	1.00	.70	.68	.00	1.10	.35	.65
13	1.58	3.95	4.90	3.15	4.25	.98	1.75	.65	.00	1.95	.25	.60
14	1.65	3.35	5.70	2.95	4.98	.98	1.30	.48	.00	1.25	.25	.65
15	1.68	3.15	4.95	2.70	5.30	.96	1.18	.42	.00	1.10	.18	.85
16	1.65	3.70	4.10	2.45	4.65	.95	.90	.48	.00	.95	.14	.95
17	1.68	4.05	3.45	2.17	4.15	.94	.75	.55	.00	1.65	.10	1.25
18	2.50	3.25	4.30	2.05	3.75	.92	.88	.75	.00	2.10	.05	1.55
19	3.45	2.85	3.95	1.98	3.15	.90	1.98	.85	.00	2.48	.25	1.40
20	4.05	3.35	3.62	1.90	2.85	.95	1.85	.95	.00	3.00	.23	1.10
21	3.50	4.10	3.40	1.86	2.25	.90	2.25	1.08	.00	1.55	.23	1.70
22	2.65	6.70	3.22	1.78	1.90	.88	1.48	.70	.00	.75	.22	2.35
23	2.05	8.45	3.03	1.75	1.88	.90	1.25	.89	.00	1.10	.20	4.10
24	1.85	11.52	2.70	1.75	1.85	.95	1.17	.75	.00	.88	.18	3.45
25	1.75	12.80	2.55	1.72	1.83	.93	.98	.58	.05	.65	.30	2.65
26	1.55	4.64	2.35	1.68	1.79	.90	.79	.42	.25	.85	.35	2.18
27	1.25	3.25	2.28	1.63	1.77	.88	.70	.35	.40	1.15	.58	1.80
28	.85	3.05	2.25	1.60	1.73	.95	.68	.30	.25	2.25	2.10	1.45
29	1.15	.....	2.15	1.57	1.66	.88	1.15	.28	.10	2.85	5.40	1.20
30	1.25	.....	2.08	1.55	1.63	.80	1.08	.28	.08	2.10	3.35	1.10
31	2.10	.....	2.03	.....	1.60	.....	.77	.25	.....	1.85	.....	.95

Daily gage height, in feet, of Staunton River at Clarksville, Virginia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.75	3.60	2.25	1.60	1.15	1.00	.....	0.35	0.30	—0.31	1.00	2.20
2	2.75	4.10	2.12	1.55	2.48	.98	.....	.31	.20	— .31	1.50	1.85
3	2.74	4.92	2.05	1.60	4.72	.96	.....	.28	.00	— .35	2.12	1.63
4	2.74	3.55	1.93	1.70	4.30	1.03	0.65	.20	.00	— .40	1.55	1.47
5	2.75	2.68	2.85	1.92	2.70	1.11	.60	.14	.00	— .45	.95	1.30
6	2.77	3.23	4.02	2.52	2.52	1.09	.57	.10	.00	— .48	.78	1.18
7	2.75	6.05	4.20	2.75	3.10	1.06	.54	.08	.00	— .52	.59	1.02
8	2.71	11.85	4.05	2.95	2.98	1.05	.51	.08	.00	— .58	.43	.84
9	2.68	8.85	3.85	2.72	2.60	1.05	.66	.09	.00	— .65	.25	.70
10	2.65	4.25	3.35	3.55	2.28	1.02	.59	.40	.00	— .40	.12	.52
11	2.62	2.58	3.45	3.15	2.85	1.98	.48	.46	.00	+ .40	.05	.40
12	2.60	2.20	4.20	2.85	3.45	1.96	.34	.31	.00	.60	.02	.37
13	2.58	3.50	4.35	2.53	3.73	.....	1.15	.29	.00	1.55	— .05	.35
14	2.65	2.85	5.15	2.30	4.43	.....	.80	.20	.00	.66	— .10	.37
15	2.68	2.55	4.37	2.05	4.72	.....	.61	.14	.00	.60	— .20	.52
16	2.65	3.15	3.60	1.75	4.10	.....	.50	.20	.00	.53	— .24	.57
17	2.68	3.70	2.97	1.46	3.65	.....	.40	.28	.00	1.05	— .30	.65
18	3.51	2.90	3.78	1.45	3.28	.....	.48	.40	.00	1.33	— .38	1.00
19	4.47	2.35	3.40	1.38	2.75	.....	1.43	.50	.00	1.79	— .10	1.02
20	5.07	2.85	3.15	1.33	2.58	.....	1.35	.65	.00	2.30	— .13	.72
21	4.52	2.90	2.90	1.28	1.70	.....	1.65	.71	.00	1.00	— .13	1.25
22	3.66	6.07	2.77	1.20	1.57	.....	1.15	.34	.00	.25	— .14	1.85
23	3.06	7.75	2.50	1.15	1.33	.....	.87	.48	.00	.60	— .16	4.50
24	2.85	10.70	2.30	1.15	1.29	.....	.84	.40	.00	.30	— .20	2.88
25	1.74	12.04	2.05	1.15	1.26	.....	.51	.30	.00	.07	— .05	2.08
26	1.54	3.05	1.98	1.12	1.21	.....	.46	.16	.00	.28	— .02	1.68
27	1.24	2.65	1.83	1.08	1.18	.....	.34	.09	.05	.62	+ .17	1.35
28	.83	2.35	1.80	1.05	1.13	.....	.32	.07	.00	1.85	1.33	1.05
29	1.14	.....	1.72	1.01	1.05	.....	.78	.30	—.23	2.40	4.70	.80
30	1.24	.....	1.68	.95	1.02	.....	.58	.80	—.28	1.33	2.77	.70
31	2.85	.....	1.65	.....	1.00	.....	.45	.50	.....	1.30	.....	.57

June 13 to July 3 no reports; repairing bridge.

NEAL STATION ON ROANOKE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 47, is on the Norfolk and Carolina Railroad bridge near Neal, North Carolina. The zero of the gage rod is over the center of the fourth floor beam of the second span from the north end of the bridge. The distance from the zero of the rod to the outer rim of the pulley is 2.47 feet, and the distance from the end of the weight to the pointer on the wire is 44.66 feet. The section is a fairly good one, for the course of the river is straight for some distance above and below the station, and the bottom is smooth. Being muddy, however, the bottom is apt to cut out in seasons of high water, and both banks are liable to overflow. The observer is W. M. Adams, Neal, North Carolina. The following measurements were made during 1897 by E. W. Myers:

January 23, gage height, 12.65 feet; discharge, 13,155 second-feet.
February 27, gage height, 27.95 feet; discharge, 64,132 second-feet.
March 17, gage height 24.71 feet; discharge, 37,659 second-feet.
May 17, gage height, 18.40 feet; discharge, 19,219 second-feet.
October 1, gage height, 1.00 feet; discharge, 1,928 second-feet.

Daily gage height, in feet, of Roanoke River at Neal, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.40	3.40	24.20	9.30	6.40	5.90	3.90	3.90	2.20	1.20	3.10	11.00
2	4.70	4.30	23.70	9.00	6.40	5.50	3.40	3.20	2.10	.80	3.40	10.10
3	5.00	11.50	19.10	8.70	6.80	5.90	3.10	2.60	2.90	.60	4.20	8.70
4	4.90	20.25	16.90	8.50	12.60	5.90	6.80	2.10	3.90	.50	5.50	7.30
5	4.90	21.50	14.90	8.40	17.10	5.30	6.90	2.00	3.40	.40	8.10	6.30
6	4.60	20.90	13.60	9.40	14.90	4.90	5.30	2.10	2.60	.30	7.50	6.90
7	4.40	21.10	15.20	11.00	12.40	5.70	3.90	1.90	2.00	.30	5.80	7.70
8	4.40	22.80	21.05	14.10	10.60	7.40	3.80	1.90	1.50	.20	4.50	7.80
9	4.50	24.30	22.25	13.40	9.10	7.50	3.30	2.40	1.10	.10	3.60	7.20
10	4.50	26.30	22.70	14.10	8.10	6.20	5.00	3.10	.90	.10	3.00	6.50
11	4.20	26.55	22.20	19.90	7.40	5.60	5.20	3.00	.80	.10	2.67	5.70
12	3.90	24.65	21.60	19.60	6.90	6.00	4.80	3.20	.60	.20	2.50	4.80
13	3.80	22.70	22.30	17.00	7.00	5.60	5.40	4.30	.50	.20	2.40	4.48
14	4.00	21.20	23.40	14.40	8.90	5.30	5.80	3.30	.50	.30	2.20	4.10
15	4.20	20.60	23.90	12.50	17.30	4.70	6.20	2.90	.40	.30	2.15	4.10
16	4.20	19.20	24.40	11.10	19.40	4.40	6.90	2.60	.30	6.40	2.10	4.15
17	4.10	18.00	24.70	10.20	19.10	4.10	6.10	2.10	.10	5.60	2.00	6.00
18	4.20	17.90	24.40	9.70	16.70	4.00	4.40	1.80	.10	3.90	1.93	7.40
19	4.60	16.70	23.40	9.40	13.70	3.90	3.40	1.40	.00	2.50	1.93	7.30
20	4.70	14.70	22.00	9.00	11.20	3.60	3.30	3.00	.10	1.80	1.93	6.20
21	5.00	14.20	20.70	8.40	9.50	5.30	5.10	2.60	.00	2.10	1.90	5.50
22	7.00	20.15	20.40	7.80	8.40	11.40	8.30	2.40	.00	2.30	1.90	5.30
23	12.65	22.45	19.30	7.40	7.80	11.50	9.90	2.30	.10	2.10	1.90	6.83
24	13.90	24.05	17.60	7.10	7.40	8.10	9.10	2.70	.20	3.70	1.80	11.00
25	13.00	25.80	15.90	6.80	7.30	5.80	7.10	4.20	.40	4.40	1.80	12.50
26	10.80	27.25	14.50	6.70	7.40	4.40	5.70	4.90	.30	4.10	1.90	4.30
27	8.60	28.00	13.40	6.60	11.00	4.10	4.90	4.20	.30	3.80	2.00	9.60
28	7.50	26.40	12.20	6.50	11.40	4.60	4.70	3.10	.80	3.70	2.00	9.30
29	5.90	.....	11.30	6.50	9.37	4.75	4.00	2.60	1.90	3.60	3.90	11.00
30	3.40	.....	10.40	6.50	7.40	4.50	3.90	2.40	1.60	3.70	11.18	11.80
31	3.10	.....	9.80	.....	6.30	.....	4.40	2.40	.....	3.40	.....	10.20

TARBORO STATION ON TAR RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 50, is on the Atlantic Coast Line bridge crossing the river at Tarboro, North Carolina. The zero of the gage is over the center of the fifth floor beam from the east end of the bridge. The outer rim of the pulley is 3 feet from the zero of the gage, and the distance from the end of the weight to the pointer on the wire is 38.30 feet. The gage reading is zero when the weight touches the bottom of the stream. The river here is a little obstructed by sand bars. The observer is R. H. Williams. The following discharge measurements were made by E. W. Myers during 1897:

January 23, gage height 6.64 feet; discharge, 3,520 second-feet.
February 26, gage height 13.51 feet; discharge, 8,106 second-feet.
March 15, gage height, 18.13 feet; discharge, 12,993 second-feet.
May 17, gage height, 6.30 feet; discharge, 3,058 second-feet.
July 29, gage height, 2.25 feet; discharge, 1,079 second-feet.
October 2, gage height, —0.65 feet; discharge, 192 second-feet.

Daily gage height, in feet, of Tar River at Tarboro, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.50	3.10	11.90	4.35	2.65	1.50	0.70	1.80	0.90	—0.60	0.80	2.20
2	3.55	5.50	10.00	4.30	4.10	1.40	.50	1.25	3.00	— .65	1.40	3.10
3	3.60	7.40	8.00	4.00	5.10	2.70	.40	1.20	5.00	— .70	2.00	3.00
4	3.31	8.90	6.90	4.30	5.90	2.20	.30	.70	3.60	— .62	4.60	2.50
5	3.25	10.20	6.20	4.95	5.10	1.75	.20	.50	2.10	— .64	4.40	2.30
6	3.22	10.22	5.60	6.10	3.80	1.50	.40	.45	1.35	— .40	3.00	2.80
7	3.15	9.60	6.60	7.50	3.30	1.35	.30	.40	1.40	— .50	2.10	3.20
8	3.00	10.10	8.55	8.50	3.10	2.00	1.05	1.30	1.00	— .60	1.50	2.80
9	2.90	11.38	10.30	7.40	2.70	2.02	.60	1.00	.70	— .70	1.65	2.40
10	2.60	12.35	11.80	7.80	2.50	1.55	.50	.90	.40	— .60	1.20	2.20
11	2.50	11.10	11.70	11.00	2.40	1.30	1.50	.50	.10	— .50	.80	1.90
12	2.45	8.09	11.10	13.40	2.25	1.35	1.63	.40	— .05	— .52	.90	1.90
13	2.55	7.00	12.80	14.90	2.35	1.15	2.50	.85	— .07	— .50	.70	1.60
14	2.60	6.98	15.00	14.50	3.80	1.10	7.20	.60	— .02	— .51	.50	1.70
15	3.00	7.51	16.50	13.60	5.40	1.10	5.80	.20	.02	— .63	.60	1.90
16	3.35	6.70	17.90	11.50	7.50	1.05	4.70	.15	— .05	— .71	.70	2.10
17	3.43	6.15	19.20	8.60	7.00	.80	2.80	.35	— .21	— .90	.50	2.20
18	3.50	6.30	19.60	6.70	4.60	1.50	2.00	.10	— .20	—1.00	.40	2.90
19	3.40	6.20	19.70	5.70	3.50	.90	1.33	— .10	— .20	— .90	.45	2.60
20	3.35	5.55	18.15	5.00	3.00	.60	1.28	— .08	— .30	— .80	.50	2.00
21	3.40	6.00	16.00	4.30	2.70	.40	1.20	— .08	— .50	— .50	.40	2.10
22	4.30	7.95	13.60	3.90	2.30	2.60	3.70	— .05	— .30	— .55	.45	2.20
23	6.25	9.62	11.30	3.70	1.80	2.10	6.05	— .15	— .40	+ .50	.65	3.30
24	8.30	11.25	9.10	3.50	1.70	1.40	5.80	.50	— .35	.80	.45	5.30
25	6.45	12.15	7.80	3.40	1.80	1.00	4.50	.60	— .40	.70	.40	6.10
26	4.80	13.30	7.00	3.10	1.60	.80	3.30	.62	— .50	.90	.35	4.20
27	4.30	13.75	6.20	3.20	1.50	.70	2.80	.40	— .60	.50	.45	4.00
28	4.40	13.00	5.40	3.00	1.90	.65	2.60	.23	— .65	.70	1.00	4.10
29	4.10	.....	4.90	2.80	2.00	1.10	2.25	.05	— .55	1.50	1.80	5.00
30	3.90	.....	4.70	2.70	1.60	1.09	2.60	.02	— .50	1.60	2.10	4.60
31	3.05	.....	4.50	.....	1.40	.....	2.30	.65	.....	1.30	.....	3.90

SELMA STATION ON NEUSE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 52, is located on the Southern Railway bridge about 3 miles from Selma, North Carolina. The zero of the gage rod is over the center of the fifth floor beam of the first span from the south end of the bridge. The distance from the zero of the gage to the outer rim of the pulley is 4 feet, and the distance from the end of the weight to the pointer on the wire is 41.05 feet. The bed of the river here is sandy and muddy and is liable to change in high water. The course of the river is straight and there is only one pier obstruction. The observer is C. Richardson, Selma, North Carolina. The following discharge measurements were made by E. W. Myers during 1897:

January 24, gage height, 6.45 feet; discharge, 1,810 second-feet.
February 23, gage height, 10.60 feet; discharge, 4,052 second-feet.
March 10, gage height, 7.95 feet; discharge, 2,639 second-feet.
May 18, gage height, 2.40 feet; discharge, 789 second-feet.
July 28, gage height, 1.60 feet; discharge, 694 second-feet.
October 1, gage height, —0.30 foot; discharge, 109 second-feet.

Daily gage height, in feet, of Neuse River at Selma, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.30	1.70	3.90	2.60	2.20	6.00	0.80	0.70	0.10	—0.30	0.00	1.80
2	1.40	2.80	3.70	2.50	3.20	4.50	1.20	.60	.10	— .30	.00	1.70
3	1.30	6.70	3.40	2.40	4.00	2.90	.80	.50	.10	— .30	.00	1.50
4	1.20	7.40	3.10	2.90	5.90	2.30	.60	.40	.10	— .30	.45	1.40
5	1.20	8.60	2.80	3.40	3.80	1.70	.50	.20	.20	— .30	.50	2.30
6	1.20	5.00	2.80	10.10	2.20	1.80	.40	.20	.20	— .30	.60	2.30
7	1.20	12.40	5.20	9.70	2.00	3.20	.70	.20	.10	— .30	1.00	2.00
8	1.10	13.20	9.90	5.80	1.90	2.60	.60	.20	.10	— .30	1.00	1.70
9	1.10	13.20	10.50	4.70	1.80	1.90	.60	.20	.10	— .30	1.00	1.30
10	1.10	7.50	8.80	14.50	1.60	1.60	1.20	.20	.10	— .30	.80	1.00
11	1.10	5.70	9.00	13.90	1.60	1.40	1.30	.20	.10	— .30	.80	1.00
12	1.10	4.40	11.20	10.50	2.20	2.10	2.20	.10	.10	— .30	.70	1.20
13	1.20	4.20	15.80	7.00	2.00	1.10	5.50	.10	.10	— .30	.40	1.10
14	1.30	4.40	14.70	5.20	5.00	1.00	5.30	.10	.10	— .30	.40	1.00
15	1.60	4.50	16.50	3.80	8.80	.90	4.80	.10	.10	— .30	.40	1.10
16	1.70	4.80	16.80	3.70	9.60	.80	2.30	.10	.10	— .30	.40	3.00
17	1.70	4.70	15.70	3.50	4.30	.70	1.20	.20	.10	— .40	.40	2.70
18	1.80	4.50	15.00	3.20	2.60	.60	1.10	.20	.10	— .40	.40	1.90
19	2.20	4.40	11.70	2.90	2.30	1.10	1.00	.10	—.10	— .30	.30	1.20
20	2.50	3.00	8.30	2.60	2.00	.50	1.30	.10	—.10	— .30	.30	1.30
21	2.90	3.50	8.20	2.40	1.90	2.20	4.10	.10	—.10	+ .10	.30	2.30
22	8.30	5.50	6.20	2.20	1.80	1.40	5.50	.80	—.10	.40	.30	4.20
23	9.30	10.60	4.60	2.10	1.60	1.10	5.60	1.40	—.10	.10	.20	5.80
24	8.00	11.40	4.20	2.00	1.60	.90	2.50	1.80	—.10	.20	.20	6.00
25	4.30	11.30	3.70	2.00	1.80	2.00	1.50	1.40	—.10	.20	.20	4.50
26	4.00	7.70	3.40	1.90	2.00	1.30	2.30	.90	—.30	.30	.20	3.00
27	3.80	7.30	3.10	1.90	2.40	.80	1.90	.50	—.30	.40	.20	3.50
28	3.40	4.50	3.00	1.90	1.80	.60	1.60	.30	—.30	.30	.20	4.10
29	2.80	.....	2.70	1.80	1.40	.70	1.60	.10	—.30	.30	1.90	4.50
30	2.50	.....	2.60	1.80	1.60	1.30	1.10	.10	—.30	.20	2.30	4.20
31	2.20	.....	2.60	.....	1.50	.....	.80	.10	.....	.00	.....	3.10

FAYETTEVILLE STATION ON CAPE FEAR RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 54, is at the bridge of the Cape Fear and Yadkin Valley Railroad, about a mile east of Fayetteville, North Carolina. The Weather Bureau has a gage fastened to the lower side of the east abutment of the covered highway bridge, this being about 400 feet above the railroad bridge, from which discharge measurements are made. For the lower 29 feet this gage consists of a rod divided into tenths and firmly fastened to the abutment. Above the 29-foot mark a scale is painted on the rock. The observer is Frank Glover, who has charge of the steamboat landing just below the railroad bridge. For his convenience he has placed a subsidiary gage at the steamboat landing reading about the same as the official gage, and from this observations are taken. The following discharge measurements were made by E. W. Myers during 1897:

March 12, gage height, 23.00 feet; discharge, 16,777 second-feet.
July 27, gage height, 7.00 feet; discharge, 2,682 second-feet.
September 30, gage height, 0.70 foot; discharge, 424 second-feet.

Daily gage height, in feet, of Cape Fear River at Fayetteville, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.20	5.50	13.40	7.70	6.10	7.00	5.00	4.70	2.20	0.70	1.90	5.50
2	6.00	5.90	11.70	8.00	10.00	8.60	3.20	3.20	4.60	.70	5.50	6.00
3	5.50	25.00	10.20	7.30	14.40	6.50	2.50	3.00	3.50	.80	9.70	5.10
4	5.50	27.00	9.00	8.00	13.20	5.00	2.00	2.70	3.00	.60	9.30	4.60
5	5.30	19.70	8.50	9.30	9.30	4.20	1.90	2.20	2.50	.70	7.20	4.30
6	5.00	15.00	7.60	27.00	8.00	4.30	3.90	2.60	2.10	.50	5.00	5.10
7	4.80	29.10	9.20	28.30	6.30	7.00	4.20	4.10	1.80	.30	4.00	5.20
8	4.60	36.50	25.60	22.00	5.60	5.50	4.80	6.80	1.50	.20	3.50	4.70
9	4.60	32.00	26.20	15.40	5.00	7.00	4.20	6.20	1.10	.20	2.90	4.10
10	4.40	24.30	20.00	23.50	4.60	7.80	4.00	6.20	1.10	.30	2.60	3.70
11	4.20	17.60	21.40	28.00	4.20	5.50	4.00	5.40	1.10	.60	2.40	3.40
12	4.10	13.00	22.00	22.70	5.20	4.40	3.90	4.30	1.10	.60	2.50	3.30
13	4.00	18.20	29.70	18.30	6.00	4.20	6.00	3.50	.90	.60	2.40	3.30
14	4.50	19.00	32.00	14.30	10.00	3.50	11.10	3.00	.80	.60	2.30	3.00
15	6.00	16.30	36.40	12.80	17.40	3.20	6.00	2.40	.70	.40	2.00	3.00
16	6.40	12.80	37.60	10.20	14.00	3.00	4.60	3.80	.60	.30	2.00	4.00
17	7.80	13.20	37.60	10.00	10.30	2.70	3.20	3.00	.30	.30	1.80	4.90
18	7.00	15.00	29.00	9.80	8.30	3.00	3.20	2.50	.80	.30	1.60	5.20
19	8.50	12.90	23.80	8.40	6.70	3.50	3.80	2.20	.80	.30	1.90	4.50
20	9.60	10.80	19.20	7.70	5.50	4.50	5.50	3.00	.90	.40	1.90	3.90
21	7.80	14.00	18.00	7.00	4.80	4.30	16.50	3.20	1.40	.90	1.70	3.50
22	20.40	24.30	16.60	6.70	4.50	3.50	25.30	5.00	1.40	1.50	1.70	3.50
23	24.55	23.50	13.70	6.30	4.30	3.00	16.40	5.20	1.10	1.60	1.70	4.80
24	16.80	23.50	11.20	5.80	4.20	2.40	12.70	6.50	1.10	1.70	1.50	9.00
25	12.60	24.20	10.00	5.50	4.30	1.80	8.50	5.60	1.10	2.00	1.40	7.80
26	8.50	23.30	9.30	5.50	4.60	4.80	6.10	4.90	1.10	2.20	1.60	5.70
27	7.20	20.40	8.40	5.20	4.50	3.40	7.00	4.00	.90	1.90	1.70	6.00
28	7.00	16.60	8.00	4.70	4.40	2.80	7.30	3.50	1.10	1.90	1.90	10.00
29	6.60	.....	7.40	4.50	4.00	3.70	6.90	2.90	.80	1.70	2.30	9.50
30	5.90	.....	7.20	4.40	4.40	4.00	5.60	2.50	.70	1.90	3.50	7.10
31	5.60	.....	7.20	.....	4.30	.....	5.00	2.50	.....	1.70	.....	5.00

SALISBURY STATION ON YADKIN RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 57, is at the Southern Railway bridge near Holtsburg, below the mouth of Grants Creek, about 4 miles from Salisbury, North Carolina. The 10-foot mark of the gage rod is opposite the center of the sixth floor beam on the lower side of the first span from the west end. The distance from the zero of the rod to the outside of the pulley wheel is 1.85 feet. The length of the wire rope and weight is 55.10 feet. The post office address of the observer, H. A. Ragle, is Sapona, North Carolina, the nearest railroad station, Holtsburg, being merely a siding. The locality is reached by wagon from Salisbury. Discharge measurements are made from the lower side of the deck bridge, the zero point being on the left bank. The channel is obstructed by three piers, with large rafts of driftwood lodged against each and sand bars below each. There are also some rocks in the river, and the bottom is rough. The following discharge measurements were made by E. W. Myers during 1897:

February 13, gage height, 4.20 feet; discharge, 10,141 second-feet.
March 20, gage height, 4.45 feet; discharge, 11,837 second-feet.
April 8, gage height, 3.90 feet; discharge, 9,992 second-feet.
August 4, gage height, 2.18 feet; discharge, 3,422 second-feet.
October 6, gage height, 1.40 feet; discharge, 1,300 second-feet.

Daily gage height, in feet, of Yadkin River at Salisbury, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.05	2.50	2.90	2.80	3.50	2.80	2.00	1.90	2.10	1.30	2.10	2.00
2	2.04	2.90	2.80	2.70	4.50	2.70	2.00	1.70	2.10	1.40	2.20	2.00
3	2.02	5.80	2.70	2.80	4.00	2.20	1.90	1.90	2.00	1.30	2.10	2.10
4	2.01	4.30	2.70	3.00	3.20	2.20	2.00	2.10	1.90	1.30	2.30	2.00
5	2.00	3.00	2.60	5.50	2.70	2.60	2.00	2.00	1.80	1.20	2.10	2.60
6	2.00	3.50	2.50	10.20	2.50	2.40	2.10	1.90	1.80	1.40	2.10	2.80
7	2.00	11.10	8.30	6.50	2.40	2.50	2.00	2.50	1.80	1.40	2.10	2.70
8	2.00	7.57	7.50	4.20	2.40	6.80	2.60	1.90	1.80	1.40	2.00	1.80
9	2.00	5.20	5.60	4.30	2.40	5.00	2.90	1.90	1.60	1.40	1.80	1.90
10	2.00	3.75	5.90	4.00	2.30	5.30	2.40	1.90	1.60	1.40	1.80	1.80
11	2.00	3.00	6.10	4.00	2.40	5.00	2.40	1.90	1.60	1.40	1.70	1.80
12	2.00	3.70	5.10	3.20	2.40	4.10	2.00	1.80	1.50	2.00	1.70	1.80
13	2.00	4.20	5.10	3.00	3.00	2.80	4.50	1.80	1.50	8.50	1.70	1.80
14	2.00	3.70	5.10	3.00	5.20	2.80	3.00	1.80	1.50	4.10	1.60	1.80
15	2.08	3.20	6.40	3.10	3.90	2.60	2.40	1.70	1.40	2.30	1.60	2.20
16	2.10	2.70	5.30	3.20	3.10	2.40	2.10	1.70	1.40	2.30	1.60	2.50
17	2.12	2.90	5.20	2.80	2.50	2.20	1.90	2.00	1.30	1.90	1.50	2.20
18	2.50	2.60	4.40	2.80	2.50	2.20	2.40	2.80	1.30	1.80	1.50	2.10
19	2.52	2.60	4.00	2.90	2.50	2.20	3.40	2.30	1.30	1.80	1.50	1.80
20	2.55	.....	4.40	2.80	2.40	2.70	3.70	1.90	1.20	2.10	1.40	1.80
21	3.40	.....	4.30	2.70	2.40	2.30	3.00	1.60	1.30	4.10	1.40	2.00
22	4.60	5.60	3.90	2.60	2.20	2.10	3.20	1.80	1.40	3.00	1.20	2.10
23	3.65	5.00	3.40	2.60	2.10	2.10	2.10	2.30	1.50	2.10	1.40	2.00
24	2.85	9.50	3.00	2.40	2.20	1.90	2.30	2.20	1.80	1.90	1.40	2.00
25	2.58	6.70	3.00	2.30	3.60	1.90	3.00	2.10	1.50	1.90	1.40	2.00
26	2.45	4.70	2.90	2.40	3.00	1.80	2.10	2.10	1.50	1.90	1.20	1.90
27	2.30	3.50	2.80	2.40	2.70	1.90	3.40	2.00	1.50	1.90	3.10	2.00
28	2.22	3.00	3.00	2.40	2.30	1.90	3.30	1.90	1.30	1.80	3.20	2.00
29	1.90	.....	2.80	2.40	2.40	2.00	2.50	2.20	1.30	1.80	3.00	2.00
30	1.88	.....	2.70	2.50	2.40	2.00	2.10	2.20	1.30	1.70	2.70	1.80
31	2.13	.....	2.80	.....	2.30	.....	1.90	2.10	.....	1.90	.....	1.80

NORWOOD STATION ON YADKIN (PEEDEE) RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 60, is near Blalocks Ferry, 1 mile above Richland Creek and about 2 miles from Norwood, North Carolina. The gage is a vertical rod divided into feet and tenths, and is securely spiked and braced to an overhanging tree near the ferry. The rod is referred to a bench mark consisting of a large nail driven into a notch cut in the root of a birch tree about 50 feet northwest of the rod, and the tree is immediately in front of the turn of the road that leads to the ferry. The zero of the gage rod is 5.93 feet below the elevation of the bench mark. The river here is broad and shallow, with smooth bottom of sand and small rocks, giving a good section for discharge measurements, which are taken from the ferryboat. The observer is W. B. Nichols, Norwood, North Carolina. The banks and bed are, for the most part, hard and permanent and the depth and current of the water very uniform. The chief variation is at a point about 100 feet from the right bank, where the water is deep and very sluggish. The following discharge measurements were made by E. W. Myers and others during 1897:

February 10, gage height, 3.32 feet; discharge, 9,607 second-feet.
March 21, gage height, 3.80 feet; discharge, 11,710 second-feet.
August 4, gage height, 1.65 feet; discharge, 3,392 second-feet.
October 6, gage height, 1.00 feet; discharge, 1,508 second-feet.
October 25, gage height, 1.48 feet; discharge, 2,715 second-feet.

Daily gage height, in feet, of Yadkin River at Norwood, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.70	1.90	2.50	2.40	2.40	2.10	1.70	1.70	1.30	1.00	1.60	2.20
2	1.70	2.70	2.30	2.30	3.80	2.10	1.60	1.50	1.50	1.00	1.70	2.00
3	1.60	3.30	2.30	2.40	4.30	1.90	1.60	1.60	1.30	1.10	1.80	1.80
4	1.60	3.50	2.20	2.60	2.90	1.80	1.90	1.60	1.30	1.10	1.80	1.70
5	1.50	2.60	2.20	6.70	2.60	1.90	1.70	1.70	1.20	1.00	1.70	2.00
6	1.50	5.50	2.60	8.50	2.30	2.40	1.40	1.50	1.20	1.00	1.50	2.00
7	1.70	8.20	6.90	6.00	2.20	2.30	1.90	2.10	1.20	1.00	1.50	2.00
8	1.70	9.20	6.80	3.80	2.10	2.40	2.10	2.50	1.10	1.00	1.40	1.80
9	1.60	4.30	4.80	4.20	2.10	4.30	1.80	2.20	1.20	1.10	1.40	1.80
10	1.50	3.40	4.30	4.20	2.10	3.40	1.70	2.00	1.20	1.00	1.30	1.70
11	1.50	2.80	5.20	3.50	2.30	3.40	1.90	1.70	1.20	1.00	1.30	1.70
12	1.50	3.10	5.40	2.90	2.50	2.50	1.80	1.60	1.10	1.10	1.40	1.40
13	1.50	3.90	4.90	2.70	2.90	2.30	3.10	1.50	1.10	3.70	1.30	1.40
14	1.60	3.40	5.40	2.50	3.50	2.20	2.80	1.50	1.00	3.80	1.30	1.30
15	1.60	2.80	6.50	2.50	3.60	2.10	2.50	1.40	1.00	2.20	1.30	1.80
16	1.70	2.60	5.00	2.40	2.80	2.10	1.70	1.40	.90	1.90	1.30	1.90
17	1.70	2.70	4.90	2.70	2.40	2.10	1.60	1.50	.80	1.60	1.20	2.00
18	2.00	2.40	3.90	2.50	2.30	1.80	2.10	2.30	.90	1.30	1.40	1.80
19	2.30	2.30	3.50	2.30	2.10	1.90	1.80	2.00	1.00	1.20	1.30	1.70
20	2.50	2.10	3.60	2.20	2.10	1.90	2.50	1.70	1.10	1.20	1.30	1.70
21	4.50	3.70	3.80	2.30	2.00	1.80	4.50	1.50	1.20	1.40	1.30	1.60
22	4.40	3.40	3.30	2.20	2.00	2.10	3.50	2.40	1.10	2.30	1.20	1.80
23	3.50	4.30	3.00	2.10	2.10	2.10	2.70	1.50	1.10	1.90	1.30	1.40
24	2.50	7.70	2.80	2.20	2.00	2.00	2.40	2.00	1.00	1.60	1.20	1.70
25	2.30	6.20	2.60	2.10	2.20	1.90	2.00	1.90	1.20	1.50	1.20	1.70
26	2.10	3.50	2.60	2.10	3.10	1.80	2.10	1.80	1.50	1.50	1.20	2.00
27	2.00	2.90	2.50	2.30	2.20	1.60	2.40	1.90	1.30	1.40	1.50	2.40
28	1.90	2.50	2.50	2.20	2.00	1.60	3.50	1.70	1.20	1.40	3.00	2.70
29	1.80	.....	2.30	2.10	1.90	1.90	2.30	1.60	1.10	1.40	2.50	2.40
30	1.80	.....	2.30	2.30	2.00	1.70	1.90	1.40	1.10	1.30	2.40	2.00
31	.....	.....	2.40	.....	2.00	.....	1.70	1.40	.....	1.40	.....	1.90

CATAWBA STATION ON CATAWBA RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 64, is located at the Southern Railway bridge about one-half a mile from Catawba, North Carolina. The zero of the gage rod is 23 feet east of the west end of the second span of the bridge, and the distance from the zero of the gage rod to the outer rim of the pulley is 3 feet. The distance from the end of the weight to the marker on the wire is 35.58 feet, the reading being zero when the weight touches bottom. The river is straight for several hundred yards above and below the bridge, and the current velocity is evenly distributed across the stream. The observer is E. M. Brawley, Catawba, North Carolina. Discharge measurements are made from a plank walk underneath the bridge. The channel is obstructed by three piers and riprap and by two trestles of false work. The section is otherwise good. The following discharge measurements were made by E. W. Myers and others during 1897:

February 8, gage height, 5.51 feet; discharge, 9,711 second-feet.
August 3, gage height, 1.90 feet; discharge, 1,358 second-feet.
October 5, gage height, 1.60 feet; discharge, 775 second-feet.
October 26, gage height, 1.82 feet; discharge, 1,279 second-feet.

Daily gage height, in feet, of Catawba River at Catawba, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.82	2.25	2.75	2.85	6.00	2.15	2.00	1.95	1.70	1.60	2.00	2.15
2	1.85	4.00	2.45	2.90	4.00	2.10	2.00	1.85	1.70	1.60	3.00	2.10
3	1.88	3.65	2.35	4.00	3.90	2.05	2.00	1.80	1.65	1.60	2.50	2.05
4	1.82	3.10	2.30	4.25	3.45	2.00	2.00	2.30	1.65	1.60	2.00	2.05
5	2.22	2.60	2.25	16.00	3.20	2.75	2.05	2.90	1.70	1.60	1.90	2.00
6	2.00	15.90	8.27	8.20	2.90	2.50	2.30	3.00	1.70	1.60	1.85	2.00
7	1.95	9.62	4.50	5.75	2.80	2.90	2.20	2.60	1.70	1.60	1.85	1.95
8	1.90	5.82	2.90	3.90	2.70	3.40	3.30	2.50	1.70	1.60	1.85	1.90
9	1.90	3.90	5.50	4.00	2.70	3.40	2.80	2.60	1.70	1.60	1.75	1.90
10	1.95	3.60	6.00	3.80	2.75	2.90	2.50	2.50	1.70	1.70	1.75	1.90
11	1.95	3.40	5.50	3.60	2.80	2.65	2.30	2.40	1.70	3.00	1.70	1.90
12	1.95	4.65	5.00	3.25	2.80	2.40	2.25	2.25	1.70	8.00	1.70	1.90
13	1.95	4.10	6.20	3.02	4.20	2.35	2.40	2.10	1.70	4.00	1.70	1.85
14	1.95	3.50	6.00	3.00	3.30	2.30	2.30	2.00	1.70	2.50	1.70	1.85
15	1.95	3.40	5.90	3.05	2.90	2.25	2.25	2.00	1.70	2.00	1.70	1.85
16	2.00	4.20	5.80	3.02	2.50	2.20	2.25	1.90	1.70	1.90	1.70	1.85
17	2.00	3.80	5.50	3.00	2.45	2.35	2.30	1.85	1.70	1.90	1.70	1.85
18	2.20	7.80	4.40	2.95	2.45	2.40	2.30	1.80	1.70	2.50	1.70	1.85
19	2.00	2.75	4.00	2.85	2.40	2.50	2.25	1.80	1.70	2.40	1.70	1.85
20	2.20	2.85	4.75	2.85	2.40	2.30	2.30	1.80	1.70	2.25	1.70	1.90
21	4.45	3.20	4.30	2.80	2.40	2.20	2.90	1.80	1.70	2.00	1.70	2.50
22	3.80	3.10	3.70	2.82	2.30	2.15	2.75	1.75	1.80	1.90	1.70	2.50
23	3.25	10.10	3.40	2.80	2.25	2.10	2.75	1.75	2.10	1.80	1.70	2.40
24	2.45	7.60	3.20	2.78	2.20	2.10	2.80	1.75	2.05	1.75	1.70	2.30
25	2.30	4.25	3.00	2.75	2.20	2.10	2.75	1.75	2.00	1.75	1.70	2.25
26	2.20	3.60	2.95	2.75	2.50	2.05	2.60	1.70	2.00	1.80	2.50	2.25
27	2.15	3.05	2.85	2.75	2.30	2.05	2.70	1.70	1.95	1.80	3.00	2.20
28	2.00	2.90	2.80	2.75	2.25	2.00	2.60	1.70	1.90	1.80	2.50	2.20
29	1.85	.....	2.82	2.80	2.20	2.00	2.50	1.70	1.80	1.80	2.25	2.15
30	2.50	.....	2.85	3.90	2.20	2.00	2.35	1.70	1.70	1.75	2.20	2.15
31	2.35	.....	2.85	.....	2.15	.....	2.15	1.70	.....	1.70	.....	2.00

ROCKHILL STATION ON CATAWBA RIVER.

This station, described in the Eighteen Annual Report, Part IV, page 61, is located at the bridge of the Southern Railway 3 miles south of Fort Mill, South Carolina. The gage is fastened to the upper side of the guard rail, the 2-foot mark of the rod being about the center of the second vertical of the second truss from the south end of the bridge. The distance from the zero of the rod to the outside edge of the pulley wheel is 1.30 feet, and the length of wire rope to the end of the weight is 52.96 feet. The observer is W. A. Morris, Rockhill, South Carolina. This station is reached from Rockhill by team. The bridge is high and long; the bed of the stream is on solid rock and is very rough. The current is at an angle with the bridge, and is swift, so that altogether the section is very poor. The following discharge measurements were made by E. W. Myers and others during 1897:

February 9, gage height, 5.00 feet; discharge, 9,711 second-feet.
April 6, gage height, 12.10 feet; discharge, 46,040 second-feet.
August 15, gage height, 1.55 feet; discharge, 2,006 second-feet.
October 8, gage height, 1.21 feet; discharge, 1,532 second-feet.
November 1, gage height, 1.45 feet; discharge, 2,619 second-feet.

Daily gage height, in feet, of Catawba River at Rockhill, South Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.80	1.85	2.60	2.50	2.70	2.00	1.70	1.45	1.40	1.20	1.40	1.85
2	1.75	2.70	2.50	2.40	2.90	1.90	1.60	1.45	1.40	1.20	1.50	1.60
3	1.70	3.30	2.40	2.40	4.40	1.90	1.50	1.50	1.40	1.20	1.55	1.70
4	1.70	3.30	2.30	2.60	3.20	1.80	1.50	1.60	1.40	1.20	1.95	1.80
5	1.70	2.70	2.30	10.30	2.70	2.60	1.60	1.60	1.40	1.20	1.70	1.85
6	1.70	8.50	2.30	13.30	2.50	2.40	1.80	1.90	1.30	1.20	1.60	1.90
7	1.90	14.75	7.70	7.00	2.40	2.20	1.60	2.20	1.30	1.20	1.50	1.80
8	1.80	10.20	7.60	4.00	2.30	4.30	2.30	2.45	1.30	1.20	1.50	1.70
9	1.80	5.00	4.50	3.50	2.30	3.60	2.30	2.10	1.30	1.20	1.50	1.70
10	1.70	3.60	4.80	3.30	2.20	3.00	2.20	1.90	1.30	1.20	1.50	1.60
11	1.70	3.20	5.70	3.50	2.20	2.70	2.00	4.70	1.25	1.30	1.50	1.60
12	1.70	3.50	5.30	3.00	2.20	2.30	1.80	2.50	1.20	1.65	1.45	1.60
13	1.70	3.70	5.60	2.90	2.40	2.30	2.40	1.80	1.20	4.80	1.40	1.60
14	1.70	3.50	6.40	2.80	4.20	2.00	2.30	1.65	1.20	2.90	1.40	1.55
15	1.70	3.20	7.10	2.70	2.90	2.00	2.10	1.60	1.20	2.00	1.40	1.60
16	1.80	3.00	5.10	2.80	2.45	2.00	1.70	1.90	1.20	1.65	1.40	1.70
17	1.80	2.90	5.00	2.80	2.25	1.90	1.55	1.70	1.20	1.50	1.40	1.90
18	1.90	2.70	4.50	2.60	2.20	2.00	1.70	1.60	1.20	1.45	1.40	1.75
19	1.90	2.50	3.70	2.50	2.20	2.00	1.60	1.70	1.20	1.40	1.40	1.70
20	2.00	2.50	4.20	2.45	2.10	1.90	2.00	1.60	1.20	1.45	1.40	1.65
21	3.60	3.30	4.10	2.40	2.20	2.20	2.35	1.50	1.50	1.50	1.40	1.70
22	3.70	3.00	3.60	2.35	2.00	1.90	5.25	1.60	1.30	2.30	1.40	1.90
23	3.10	3.00	3.20	2.30	2.00	1.70	2.60	1.60	1.25	1.80	1.40	2.00
24	2.50	7.80	3.00	2.30	2.00	1.65	2.00	1.80	1.25	1.60	1.40	2.00
25	2.30	4.80	2.90	2.30	2.10	1.60	1.70	2.00	1.50	1.50	1.40	1.90
26	2.10	3.50	2.70	2.20	2.10	1.90	1.60	1.70	1.60	1.50	1.40	1.85
27	2.00	3.10	2.60	2.30	2.00	1.70	2.30	1.60	1.40	1.50	2.40	2.10
28	2.00	2.70	2.50	2.40	1.90	1.70	2.00	1.50	1.35	1.45	2.70	2.20
29	1.90	.....	2.50	2.20	1.90	1.70	1.80	1.50	1.30	1.45	2.15	2.10
30	1.70	.....	2.40	2.20	2.00	1.70	1.60	1.45	1.30	1.45	2.10	1.90
31	1.70	.....	2.55	.....	1.90	.....	1.50	1.45	.....	1.40	.....	1.80

GAFFNEY STATION ON BROAD RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 65, is at the Southern Railway bridge about 3 miles from Gaffney, South Carolina. The zero of the gage is 18 feet east of the west end of the third span of the bridge from the east. The distance from the zero of the gage to the rim of the pulley is 2.5 feet, and that from the end of the weight to the pointer on the wire is 50.71 feet. The river here is straight for several hundred yards above and below the bridge, but the section is not a good one, as the right bank is subject to overflow in very high water. This station is reached from Blacksburg, South Carolina. The readings of river heights are made at the railroad bridge, where the section is poor. Measurements of discharge are made from the ferryboat located one-fourth mile above. There the section is very good. The bottom is sandy, but the current is sluggish at the left bank. The observer is J. M. Gaffney. The following discharge measurements were made by E. W. Myers and others during 1897:

March 9, gage height, 2.85; discharge, 4,364 second-feet.
April 7, gage height, 3.49 feet; discharge, 5,324 second-feet.
August 6, gage height, 1.65 feet; discharge, 1,297 second-feet.
October 9, gage height, 0.92 foot; discharge, 829 second-feet.
October 31, gage height, 1.38 feet; discharge, 861 second-feet.

Daily gage height, in feet, of Broad River at Gaffney, South Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.84	1.25	1.19	2.25	3.24	3.09	3.13	1.89	1.79	0.95	1.03	2.43
2	.89	2.12	1.87	2.09	4.32	3.05	3.11	1.79	1.74	.92	1.69	2.44
3	.87	2.59	1.88	2.07	4.01	3.31	3.05	2.25	1.33	1.08	1.85	2.46
4	.88	2.12	1.94	2.11	3.69	3.33	3.17	2.32	1.31	.92	1.25	2.52
5	.87	1.82	1.95	8.97	3.55	8.26	8.46	2.19	1.25	1.03	1.21	1.93
6	.93	8.69	3.87	5.95	3.27	3.45	3.21	2.25	1.23	1.05	1.19	1.92
7	.94	7.48	6.00	3.85	3.29	3.51	4.09	2.32	1.21	.89	1.25	1.42
8	.91	4.05	3.32	3.29	3.28	5.45	3.68	2.75	1.03	1.02	1.08	1.23
9	.87	3.19	2.87	3.09	3.64	3.20	4.01	2.22	1.01	.92	1.06	1.46
10	.91	2.82	3.39	3.25	3.61	3.09	3.64	2.09	1.12	.79	1.04	1.31
11	.87	2.55	3.69	2.81	3.71	3.03	3.37	2.07	1.02	.81	1.03	1.21
12	.96	2.75	3.94	2.54	3.60	3.09	3.01	2.19	.95	4.19	1.01	1.35
13	.92	2.97	4.65	2.49	3.69	3.14	4.07	2.08	.80	2.91	1.02	1.19
14	.87	2.69	4.52	2.31	3.80	3.29	3.28	1.82	1.00	1.59	1.11	1.21
15	.89	2.45	4.81	2.39	3.55	2.89	3.11	1.91	.89	1.39	1.13	1.59
16	.85	2.28	3.64	2.54	3.73	2.81	3.09	1.99	.82	1.18	1.25	1.35
17	.86	2.24	3.77	2.31	3.39	2.65	3.02	2.01	.92	1.29	1.41	1.25
18	.92	2.11	3.11	2.28	3.09	3.05	3.11	1.69	.96	1.31	1.31	1.38
19	1.15	1.99	2.81	2.05	3.19	3.41	3.05	1.55	.95	1.28	1.28	1.36
20	1.09	1.92	3.81	2.07	3.39	3.61	2.08	1.57	.89	1.25	1.32	1.41
21	2.05	2.27	3.22	2.02	3.24	3.59	2.49	1.41	1.19	1.52	1.01	1.38
22	2.32	2.11	2.85	1.98	3.33	3.42	3.54	1.51	.92	1.41	.98	1.42
23	1.79	2.24	2.62	1.97	3.20	3.28	2.29	1.59	1.39	1.15	1.02	1.68
24	1.58	3.73	2.52	2.14	3.09	3.19	2.08	2.39	1.30	1.25	1.29	1.79
25	1.62	2.67	2.39	2.98	3.25	3.11	2.21	1.61	1.09	1.23	1.41	1.59
26	1.47	2.33	2.29	2.92	3.35	3.02	2.04	1.38	1.02	1.22	1.35	1.87
27	1.39	2.16	2.21	3.02	3.11	3.04	2.29	1.85	.85	1.24	2.51	2.01
28	1.35	2.08	2.16	2.97	3.18	3.42	2.34	1.81	1.25	1.22	2.41	2.09
29	1.25	.....	2.09	2.91	3.21	3.43	2.05	1.82	1.08	1.21	2.39	1.62
30	1.36	.....	1.89	3.17	3.13	3.11	2.01	1.42	1.02	1.23	2.45	1.58
31	1.52	.....	2.13	.....	3.21	.....	2.02	1.81	.....	1.05	.....	1.51

ALSTON STATION ON BROAD RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 67, is located at the Southern Railway bridge, about 200 yards from Alston, South Carolina. The zero of the gage is over the center of the fourth floor beam of the second span from the east end of the bridge. The outer rim of the pulley is 4 feet from the zero of the gage, and the distance from the end of the weight to the pointer on the wire is 42.65 feet, the gage reading zero when the end of the weight touches bottom. The section here is not a very good one, being broken by the foundations of an old bridge crossing at the same place as the present one, and the bottom is soft and muddy. The river is straight for a long distance above and below the station, and the current velocity is fairly uniform all the way across. The observer is D. R. Elkin, Alston, South Carolina. The following discharge measurements were made by E. W. Myers and A. P. Davis during 1897:

August 17, gage height, 2.76 feet; discharge, 2,515 second-feet.
November 2, gage height, 2.90 feet; discharge, 2,729 second-feet.

Daily gage height, in feet, of Broad River at Alston, South Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.01	3.10	4.62	7.00	4.70	3.45	3.71	2.84	2.51	3.55	2.47	3.86
2	3.05	6.50	4.18	6.48	5.61	3.40	3.33	2.60	5.76	2.43	2.97	3.57
3	3.04	7.12	4.20	6.90	6.27	3.50	3.10	2.54	3.64	2.42	3.88	3.56
4	3.01	8.91	4.10	7.70	5.40	3.40	3.05	3.42	3.25	2.23	4.10	3.55
5	2.93	10.00	3.96	14.39	4.45	3.42	4.75	3.03	2.91	2.13	3.35	3.62
6	3.09	17.03	5.66	18.82	4.32	6.70	4.15	3.31	2.62	2.40	2.91	3.76
7	3.11	21.97	12.10	14.40	4.10	7.27	3.92	4.56	2.35	2.53	3.15	3.68
8	3.00	19.03	8.72	10.66	3.90	14.20	3.75	5.20	2.53	2.34	3.00	3.62
9	3.00	12.00	6.75	9.50	3.95	13.64	3.59	3.20	2.51	2.50	2.80	3.80
10	2.89	7.00	5.80	6.83	3.98	9.71	3.95	3.35	2.61	2.43	3.11	3.45
11	2.75	5.50	7.50	6.12	4.10	9.03	3.64	3.11	2.60	2.65	3.00	3.16
12	2.80	9.75	7.10	5.63	3.85	4.50	3.70	3.28	2.45	5.72	2.90	3.15
13	2.97	9.10	11.04	5.43	3.65	4.00	3.70	3.15	2.31	8.93	2.91	3.10
14	3.10	8.50	13.00	5.23	5.44	4.15	3.45	2.98	2.10	7.14	2.90	3.00
15	3.14	5.60	14.40	5.10	4.68	3.90	3.31	4.10	2.37	4.78	2.86	3.45
16	3.00	7.25	11.40	5.10	4.00	3.74	3.30	3.89	2.00	3.50	2.70	3.45
17	3.01	6.23	9.70	4.90	4.03	3.45	3.08	2.89	2.21	3.34	2.78	3.50
18	3.05	5.02	9.00	4.65	3.63	3.42	3.76	2.96	2.24	2.70	2.76	3.30
19	3.76	4.03	7.02	4.47	3.60	3.31	3.15	3.01	2.31	2.60	2.71	3.07
20	3.55	4.50	7.80	4.31	3.51	3.00	5.10	2.85	2.21	3.10	2.86	3.07
21	8.65	5.75	7.85	4.35	3.50	3.21	7.40	2.71	2.40	3.70	2.83	3.00
22	9.52	5.50	6.81	4.20	3.42	3.30	5.71	8.20	3.10	3.47	2.82	3.50
23	6.65	6.70	6.15	4.30	3.51	3.51	4.82	5.04	3.41	3.31	2.79	4.08
24	5.63	6.23	5.96	4.00	3.98	3.73	3.80	3.35	3.83	3.30	2.75	3.85
25	5.03	7.10	5.32	4.01	3.65	4.40	3.61	3.26	3.80	3.00	3.00	3.60
26	4.00	5.70	5.00	4.05	3.41	3.50	3.06	3.11	3.16	2.77	3.21	3.30
27	3.75	5.30	4.81	3.92	3.40	3.55	3.90	3.00	2.98	3.03	3.05	4.50
28	3.55	4.55	4.52	4.17	3.30	5.81	4.01	3.10	2.55	2.90	4.20	4.76
29	3.31	.....	4.23	3.89	3.21	3.70	3.65	2.85	2.58	2.77	5.56	4.12
30	3.02	.....	4.40	3.85	3.28	3.91	3.15	2.73	2.71	2.91	5.12	3.90
31	3.20	.....	4.90	.....	3.30	.....	2.96	2.30	.....	2.50	.....	3.74

WATERLOO STATION ON SALUDA RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 68, is 1 mile below the mouth of Reedy River, at the Port Royal and Western Carolina Railroad bridge, about 3 miles from Coronaca station, South Carolina. The zero of the gage is over the center of the sixth floor beam of the first span from the east end of the bridge. The distance from the zero of the gage to the outer rim of the pulley is 2.75 feet, and that from the end of the weight to the pointer on the wire is 47.0 feet. The river here is straight for several hundred yards above and below the bridge. The bottom is of sand and mud and seemingly liable to change by high water, and the right bank is subject to overflow. The observer is R. N. Cunningham, Waterloo, South Carolina. The locality is reached from Greenwood, South Carolina. The channel is broken by one pier and the bottom is muddy, but with these exceptions the section is excellent. Discharge measurements are made from the railroad bridge. The following discharge measurements were made, the first by E. W. Myers and the next by A. P. Davis, during 1897:

August 17, gage height, 3.35 feet; discharge, 665 second-feet.
November 2, gage height, 4.31 feet; discharge, 1,242 second-feet.

Daily gage height, in feet, of Saluda River at Waterloo, South Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.35	4.75	4.30	6.25	8.35	3.55	4.75	2.80	3.75	3.30	3.20	4.85
2	4.50	7.35	4.80	6.00	9.30	3.70	4.65	2.68	3.75	4.05	4.50	4.75
3	3.70	7.70	5.25	6.55	6.05	5.70	4.30	3.50	3.50	2.85	5.13	4.25
4	4.00	6.20	5.25	8.00	5.50	4.85	3.70	3.60	4.35	2.30	4.77	4.80
5	4.35	5.35	5.05	12.10	5.30	5.25	6.20	3.50	3.20	3.95	4.60	4.00
6	4.40	15.70	8.30	13.95	5.20	6.57	4.15	4.05	2.50	3.80	4.60	4.40
7	4.35	16.58	10.05	17.00	5.00	5.75	4.20	3.75	3.40	2.64	3.60	4.10
8	4.35	14.30	7.75	8.70	5.20	10.35	4.82	3.35	4.00	3.58	2.85	3.95
9	4.40	7.95	6.20	8.05	5.65	12.25	3.85	3.05	3.55	3.00	4.50	3.95
10	3.55	6.40	5.80	7.80	5.15	6.40	4.85	3.55	3.10	3.45	4.35	4.58
11	3.75	8.90	6.00	7.15	4.60	5.55	4.10	3.85	3.25	3.95	4.35	4.68
12	4.30	9.05	9.30	6.75	4.50	5.25	3.10	4.30	3.18	4.50	4.10	3.60
13	4.40	8.25	10.35	6.25	5.10	5.50	5.70	4.20	2.40	7.30	4.30	3.80
14	4.95	7.25	12.60	6.20	5.00	4.20	3.90	4.25	4.00	5.15	4.00	4.75
15	5.85	5.50	12.40	5.70	5.35	4.00	3.75	3.15	3.90	4.85	2.85	4.65
16	4.60	6.35	9.50	6.00	5.60	7.35	3.75	2.55	3.17	4.55	4.15	4.50
17	3.95	6.00	8.35	5.80	4.40	4.15	5.00	4.15	2.90	3.40	4.35	4.75
18	4.65	5.65	7.55	6.25	4.25	4.90	3.90	4.25	2.72	2.50	4.30	4.70
19	4.95	5.60	6.80	5.70	4.15	4.85	3.70	3.75	3.10	3.75	4.15	3.65
20	5.10	5.35	8.40	5.40	4.45	5.00	4.00	4.40	2.40	4.40	3.95	3.40
21	10.80	6.15	8.10	5.15	4.90	3.50	3.70	6.10	3.45	4.55	3.95	4.00
22	8.55	5.80	7.00	5.10	4.85	3.75	3.90	5.35	3.35	4.50	2.70	4.20
23	5.70	7.45	6.45	5.07	5.20	4.10	4.05	3.20	4.75	4.45	3.85	4.90
24	5.60	6.50	6.15	5.40	3.55	4.10	4.05	4.40	4.90	3.55	4.28	3.95
25	4.80	6.55	6.00	6.35	4.00	4.10	4.15	3.35	4.52	3.40	4.20	3.45
26	4.40	6.00	5.60	4.90	4.85	4.15	3.30	4.20	3.58	4.50	4.12	3.65
27	4.35	5.60	9.55	4.80	3.95	3.20	4.00	4.35	2.75	4.20	5.76	3.55
28	3.95	6.70	6.35	4.75	4.80	3.30	3.65	3.50	3.78	3.80	5.75	4.85
29	4.05	.....	5.00	4.65	3.85	4.30	3.60	3.15	3.80	3.95	5.05	4.75
30	4.50	.....	5.10	4.85	5.10	3.75	4.60	2.50	3.55	3.50	5.25	4.65
31	4.20	.....	5.70	.....	3.25	.....	5.00	3.50	.....	3.25	.....	4.77

CALHOUN FALLS STATION ON SAVANNAH RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 73, is at the Seaboard Air Line bridge across the Savannah River above the mouth of Beaverdam Creek and below Rocky River, and about 3 miles west of the town of Calhoun Falls, South Carolina. The river here is divided into two channels by a large island, containing several hundred acres. The east channel is a good section at ordinary stages, but at lowest water the current is very sluggish. The west channel, which is the main river, is obstructed by some very small islands and old cofferdams about the two piers; otherwise the section is excellent. Peter Pfeiffer, a farmer, is the observer.

The wire gage is on the west channel, center span. The rod is 14 feet long, and is nailed to guard rail on east side of pulley on downstream side of bridge. The center of the 3-inch pulley is 193 feet from the initial point, and is 55.20 feet gage height. Zero point on the rod is 10 feet from the center of the pulley. The wire cable from bottom of weight to the index is 65.40 feet. One bench mark on the top of the iron stringer under the cross-ties near the gage is 54.0 feet above the datum of the gage. The other is on the top of the east end of the pier, west channel, and is 30.85 feet above zero of gage. The following discharge measurements were made by B. M. Hall and Max Hall during 1897:

January 20, gage height, 2.90 feet; discharge, 4,204 second-feet.
April 28, gage height, 3.21 feet; discharge, 6,446 second-feet.
June 12, gage height, 2.80 feet; discharge, 4,469 second-feet.
September 29, gage height, 1.90 feet; discharge, 1,693 second-feet.
November 3, gage height, 2.92 feet; discharge, 3,812 second-feet.

Daily gage height, in feet, of Savannah River at Calhoun Falls, South Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.50	2.80	3.00	5.40	3.80	2.20	2.80	2.50	2.20	1.80	2.55	2.80
2	2.40	5.20	2.95	6.90	5.65	2.15	2.65	2.40	2.40	1.80	3.40	2.70
3	2.40	4.00	2.80	5.20	4.30	3.05	2.55	2.35	2.30	1.85	3.05	2.85
4	2.40	3.60	2.80	4.75	3.95	4.40	2.40	2.25	2.25	1.85	2.70	3.00
5	2.35	3.25	2.75	11.65	3.85	4.10	2.30	2.10	2.05	1.80	2.55	2.90
6	2.35	6.00	2.65	13.35	3.80	3.10	3.05	2.65	2.00	1.75	2.45	2.75
7	2.30	8.55	6.80	8.15	3.70	2.95	2.50	2.95	1.95	1.75	2.35	2.70
8	2.25	7.20	4.65	4.95	3.65	3.05	2.40	2.90	1.95	1.70	2.25	2.60
9	2.25	5.05	4.20	4.05	3.40	3.25	2.65	2.70	1.90	1.65	2.20	2.55
10	2.25	4.10	4.00	4.00	3.25	3.05	2.45	2.60	1.85	1.75	2.20	2.55
11	2.20	3.85	4.40	4.15	3.15	2.95	2.50	2.40	1.80	2.25	2.15	2.50
12	2.20	5.15	5.50	4.10	3.05	2.80	2.55	2.30	1.80	2.65	2.10	2.40
13	2.30	4.40	7.75	4.00	3.00	3.00	3.25	2.25	1.85	2.40	2.10	2.35
14	3.05	4.10	7.25	3.95	3.05	2.85	2.65	2.20	1.80	2.25	2.05	2.95
15	2.75	4.00	6.00	3.95	3.10	2.80	2.55	2.15	1.80	2.20	2.00	2.80
16	2.60	4.05	5.20	3.85	3.15	3.00	2.45	2.20	1.75	2.15	2.00	2.70
17	2.55	3.95	4.15	3.80	3.10	3.05	2.50	2.25	1.75	2.10	2.05	2.65
18	3.35	3.80	3.85	3.75	3.05	2.95	3.90	2.20	1.70	2.15	2.00	2.55
19	3.10	3.65	3.50	3.65	3.00	2.85	3.30	2.30	1.70	2.40	2.00	2.50
20	2.90	3.70	4.00	3.50	2.95	2.80	3.10	2.25	1.75	3.05	1.95	2.45
21	5.40	3.50	5.35	3.40	2.90	2.70	4.05	2.20	1.75	2.60	1.95	2.50
22	3.95	3.35	4.40	3.35	2.90	2.65	3.45	2.70	1.85	2.40	1.90	2.65
23	3.60	4.05	4.10	3.30	2.85	2.55	3.00	2.60	2.75	2.35	1.90	2.60
24	3.20	3.80	4.00	3.25	2.75	2.55	2.75	2.40	2.25	2.30	1.85	2.55
25	3.10	4.00	3.90	3.25	2.70	2.45	2.65	2.30	2.05	2.25	1.85	2.50
26	3.00	3.90	3.65	3.30	2.60	2.50	2.95	2.25	2.00	2.30	2.00	2.50
27	2.95	3.45	3.05	3.25	2.55	2.40	3.50	2.20	2.00	2.25	3.25	2.40
28	2.95	3.20	3.40	3.20	2.40	2.30	3.00	2.15	1.95	2.20	3.05	2.40
29	2.90	.....	3.25	3.25	2.35	3.50	2.90	2.10	1.90	2.20	2.95	2.35
30	2.90	.....	3.25	3.40	2.25	2.95	2.70	2.00	1.85	2.15	2.85	2.35
31	2.75	.....	3.30	.....	2.20	.....	2.55	2.05	.....	2.10	.....	2.30

CARLTON STATION ON BROAD RIVER.

This station is located on the railroad bridge of the Seaboard Air Line, 3 miles east of Carlton, Georgia, and 3 miles above the mouth of South Fork. The iron bridge is 250 feet long and is approached on each side by wood trestles. The banks are both liable to overflow to the extent of the trestles. The initial point for sounding is the end of iron bridge at right bank, upstream. The rod of the wire gage is fastened to outside of guard rail on the upstream side of bridge. Its zero is 37.0 feet from initial point and 4.0 feet from center of pulley. Bench mark is top of upstream iron girder under cross-ties at 30 feet from initial point and is 51.0 feet above datum. Center of pulley is 52.20 feet above datum. Length of wire from index to bottom of weight is 56.30 feet. The observer is S. P. Power, jr.

The following discharge measurements were made during 1897 by Max Hall and others:

May 27, gage height, 2.10 feet; discharge, 596 second-feet.
June 22, gage height, 1.92 feet; discharge, 580 second-feet.
July 28, gage height, 2.24 feet; discharge, 920 second-feet.
August 17, gage height, 2.25 feet; discharge, 865 second-feet.
September 27, gage height, 1.60 feet; discharge, 358 second-feet.
October 29, gage height, 1.67 feet; discharge, 407 second-feet.
November 10, gage height, 1.70 feet; discharge, 395 second-feet.
December 10, gage height, 2.00 feet; discharge, 615 second-feet.

September 28, a measurement of Broad River, below mouth of South Fork, from a boat, gave a discharge of 472 second-feet. On same date a measurement of South Fork, just above mouth, gave a discharge of 150 second-feet.

Daily gage height, in feet, of Broad River at Carlton, Georgia, for 1897.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1....	1.85	1.85	1.70	1.50	1.65	2.20	17.....	1.85	3.30	1.50	1.60	1.70	2.00
2....	1.85	1.85	2.00	1.50	2.40	2.10	18.....	3.60	2.00	1.50	1.80	1.70	2.00
3....	1.80	1.80	2.30	1.50	2.25	2.20	19.....	4.90	1.90	1.50	2.00	1.65	2.05
4....	1.80	1.80	1.85	1.50	1.95	2.70	20.....	6.30	2.00	1.50	2.40	1.65	2.10
5....	2.00	1.80	1.80	1.50	1.80	2.55	21.....	5.30	1.95	1.50	2.20	1.70	2.10
6....	2.00	1.75	1.70	1.50	1.80	2.50	22.....	3.85	2.15	1.50	2.10	1.70	2.15
7....	1.90	2.60	1.60	1.50	1.80	2.30	23.....	2.90	2.00	1.70	1.80	1.70	2.40
8....	2.10	2.20	1.55	1.50	1.75	2.10	24.....	2.30	1.95	1.70	1.80	1.70	2.20
9....	2.35	2.00	1.55	1.50	1.75	2.05	25.....	2.15	1.85	1.65	1.70	1.70	2.10
10....	2.05	2.00	1.55	1.50	1.70	2.00	26.....	2.25	1.80	1.65	1.65	1.70	2.30
11....	2.55	1.95	1.55	1.60	1.70	1.95	27.....	2.15	1.75	1.60	1.70	3.15	2.65
12....	2.35	1.90	1.55	2.45	1.70	1.95	28.....	2.30	1.75	1.60	1.65	2.75	2.30
13....	1.95	1.85	1.50	2.50	1.70	1.90	29.....	2.10	1.70	1.55	1.65	2.30	2.15
14....	1.85	1.80	1.50	2.05	1.70	2.10	30.....	1.95	1.70	1.50	1.65	2.70	2.10
15....	1.80	1.80	1.50	1.85	1.70	2.30	31.....	1.90	1.65	.....	1.65	.....	2.10
16....	1.75	4.55	1.50	1.70	1.70	2.10							

October 18-25, no readings taken; gage broken; gage heights estimated.

CAREY STATION ON OCONEE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 78, is located at an iron girder deck bridge on the Georgia Railway at the station of Carey, 6 miles west of Greensboro, Georgia. It is just below the junction of the Appalachee and Oconee rivers. The observer is J. L. Carey, a farmer. The length of the wire of the gage from index to end of weight is 46.95 feet. The rod, 14 feet in length is nailed to the guard rail of the bridge on the downstream side. Its zero point is 24.8 feet from the initial point, which is the downstream end of the pier near the left bank at the end of the big iron girder. The top of the cord or iron girder 20 feet from the initial point on downstream side of bridge is 41.13 feet above datum of gage heights. Both banks are low and liable to overflow under the trestles to the end of embankments. The bed of the stream is rocky and not easily changed. The current is good. The following measurements were made by B. M. Hall and Max Hall during 1897:

January 18, gage height, 4.95 feet; discharge, 3,318 second-feet.
March 18, gage height, 5.15 feet; discharge, 4,257 second-feet.
April 29, gage height, 2.40 feet; discharge, 1,992 second-feet.
May 28, gage height, 2.10 feet; discharge, 1,047 second-feet.
June 9, gage height, 2.50 feet; discharge, 1,885 second-feet.
July 30, gage height, 1.80 feet; discharge, 1,103 second-feet.
October 4, gage height, 1.08 feet; discharge, 381 second-feet.
November 11, gage height, 1.92 feet; discharge, 678 second-feet.
December 14, gage height, 2.30 feet; discharge, 1,117 second-feet.

Daily gage height, in feet, of Oconee River at Carey, Georgia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.10	2.50	3.20	3.30	4.00	2.10	1.60	1.60	1.50	.....	2.00	2.70
2	1.90	3.80	3.20	4.90	3.80	2.10	1.50	1.50	1.20	1.50	2.20	2.40
3	2.10	3.70	3.10	6.10	3.30	2.10	1.10	1.50	1.20	1.40	2.40	2.20
4	2.00	3.60	3.90	5.60	2.80	2.20	1.10	1.50	1.40	1.10	2.00	2.60
5	2.10	3.30	3.00	8.80	2.60	2.20	1.50	1.40	1.30	1.20	1.90	2.80
6	2.00	4.60	2.90	14.40	2.50	2.30	2.70	1.90	1.20	1.40	1.80	2.70
7	2.10	5.00	6.40	12.40	2.30	2.20	2.60	2.40	.80	1.30	1.80	2.50
8	2.10	4.60	7.80	7.30	2.30	2.20	2.20	2.40	.50	1.20	1.80	2.50
9	1.80	3.80	6.80	5.40	2.30	2.50	1.60	2.20	.30	1.30	1.80	2.40
10	1.90	3.30	4.40	5.50	2.30	2.30	1.80	2.10	.30	2.90	1.90	2.30
11	2.00	3.10	4.00	4.50	2.20	2.20	1.80	2.00	.20	2.80	1.70	2.30
12	1.90	5.90	4.20	4.00	2.30	2.00	2.20	1.70	.20	2.70	1.80	2.10
13	2.00	6.60	7.70	3.50	2.30	1.80	1.70	1.50	.10	2.60	1.80	2.00
14	2.70	5.30	10.40	3.50	2.40	1.70	1.60	1.40	.30	2.30	1.70	2.30
15	4.30	4.40	12.20	3.30	2.30	1.70	1.10	1.20	.40	1.90	1.70	2.50
16	4.20	4.00	11.60	3.30	2.30	1.60	.70	1.10	.70	1.90	1.70	2.40
17	3.40	4.20	8.60	3.30	2.30	1.60	.70	2.90	1.50	1.80	1.80	2.30
18	4.50	3.60	5.50	3.00	2.20	1.60	1.80	3.10	1.40	1.60	1.90	2.10
19	4.80	3.30	4.20	2.90	2.20	1.80	3.70	3.20	1.80	1.90	1.60	2.00
20	4.00	3.00	5.30	2.80	2.20	2.40	5.60	4.10	1.50	2.10	1.80	2.00
21	6.00	3.80	5.50	2.70	2.00	2.10	5.60	3.00	1.40	2.10	1.80	2.20
22	7.80	4.00	4.60	2.70	1.90	2.00	5.80	3.70	1.40	2.00	1.80	2.30
23	6.80	3.80	4.60	2.60	2.00	1.70	5.10	2.80	1.90	2.00	1.90	2.40
24	4.30	4.70	4.70	2.60	2.20	1.50	3.10	2.60	1.80	2.10	1.80	2.40
25	3.30	5.30	4.20	2.70	2.10	2.20	2.40	2.10	1.80	2.00	1.80	2.40
26	3.10	5.20	3.70	2.50	2.10	2.00	2.40	1.80	1.70	2.00	1.70	2.40
27	2.80	4.20	3.20	2.50	2.10	1.80	2.60	1.70	1.70	1.80	2.80	2.50
28	2.80	3.50	3.20	2.50	2.00	1.60	2.30	1.60	1.70	1.80	3.50	2.60
29	2.60	.....	3.00	2.50	2.10	1.50	2.30	1.40	1.70	1.60	2.70	2.30
30	2.40	.....	3.00	2.90	2.10	1.60	1.80	1.40	1.70	1.60	2.70	2.40
31	2.50	.....	3.40	.....	2.20	.....	1.60	1.20	.....	1.80	.....	2.30

DUBLIN STATION ON OCONEE RIVER.

This station is located one-half mile east of Dublin, Georgia. The gage is vertical and is fastened to the lower side of the middle pier of the railroad bridge. Observations are taken under the direction of the Weather Bureau. The section is very good, although broken by three piers and some drift. The bed of the river is soft. The channel is straight for some distance above and below the section. The initial point for soundings is the end of iron bridge on right bank of river. The following discharge measurements were made in 1897 by B. M. Hall and P. A. Dallis:

May 5, gage height, 6.10 feet; discharge, 6,400 second-feet.
June 7, gage height, 1.90 feet; discharge, 2,861 second-feet.
June 8, gage height, 1.77 feet; discharge, 2,680 second-feet.
June 9, gage height, 1.50 feet; discharge, 2,488 second-feet.
June 10, gage height, 1.43 feet; discharge, 2,488 second-feet.
November 7, gage height, 0.40 foot; discharge, 1,644 second-feet.

Daily gage height, in feet, of Oconee River at Dublin, Georgia, from January to April, 1897.

Day.	Jan.	Feb.	Mar.	Apr.	Day.	Jan.	Feb.	Mar.	Apr.
1	2.1	2.7	12.8	8.1	17	4.8	16.0	22.7	7.2
2	2.1	3.2	13.5	10.8	18	5.0	14.6	21.4	6.8
3	2.1	5.4	13.3	12.0	19	4.6	13.1	20.0	6.4
4	2.0	6.2	9.5	14.0	20	5.2	11.7	18.0	6.6
5	2.0	6.2	7.5	15.5	21	6.0	10.2	16.0	6.4
6	1.9	6.9	7.0	15.6	22	6.0	9.2	14.7	5.0
7	1.9	8.0	7.2	15.0	23	7.2	7.6	15.5	4.5
8	1.8	8.7	8.1	14.8	24	7.8	7.5	16.2	4.4
9	1.8	9.2	8.8	16.0	25	8.4	7.8	17.0	4.3
10	1.8	9.8	9.6	16.7	26	8.4	9.9	17.7	4.1
11	1.8	9.7	10.0	16.1	27	6.4	10.5	17.0	4.0
12	1.7	10.8	10.8	14.8	28	5.2	12.0	15.5	4.0
13	1.5	11.6	11.0	13.5	29	3.8	.....	13.4	3.9
14	1.5	13.0	13.0	12.1	30	3.0	.....	10.8	4.2
15	1.5	14.3	15.5	9.0	31	2.8	.....	8.5	.....
16	1.6	16.1	20.5	8.0					

ALMON STATION ON YELLOW RIVER.

This station is located one-quarter mile east of Almon, Georgia, and 3 miles west of Covington, Georgia. It is at the low wagon bridge crossing the stream 600 feet below the Georgia Railroad bridge. The observer is A. A. Almond. The following are the discharge measurements, made by B. M. Hall and Max Hall in 1897:

September 19, 1896, gage height, 0.75 foot; discharge, 62 second-feet.
March 27, 1897, gage height, 3.90 feet; discharge, 876 second-feet.
June 21, gage height, 2.50 feet; discharge, 287 second-feet.
September 7, gage height, 1.53 feet; discharge, 123 second-feet.
December 8, gage height, 2.10 feet; discharge, 227 second-feet.

Daily gage height, in feet, of Yellow River at Almon, Georgia, from September to December, 1897.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1	.....	1.20	1.60	2.20	17	1.25	1.50	1.68	2.00
2	.....	1.10	1.65	2.80	18	1.30	1.60	1.69	2.08
3	.....	1.15	1.98	2.70	19	1.30	1.70	1.65	1.98
4	.....	1.20	1.90	2.20	20	1.22	1.80	1.64	2.00
5	.....	1.10	1.88	2.80	21	1.20	1.70	1.68	2.08
6	.....	1.15	1.70	2.90	22	1.20	1.68	1.67	2.09
7	.....	1.10	1.50	2.10	23	1.28	1.66	1.66	2.20
8	.....	1.10	1.60	2.08	24	1.35	1.60	1.70	2.18
9	.....	1.15	1.75	2.06	25	1.25	1.58	1.68	2.10
10	.....	1.20	1.70	2.00	26	1.30	1.50	1.70	2.18
11	.....	1.35	1.68	.....	27	1.35	1.40	1.70	2.10
12	1.40	1.90	1.66	1.98	28	1.30	1.40	1.76	2.00
13	1.30	1.98	1.64	1.95	29	1.28	1.45	1.80	1.98
14	1.42	1.90	1.64	1.89	30	1.24	1.50	2.00	2.00
15	1.40	1.80	1.64	1.86	31	.....	1.50	.....	2.04
16	1.30	1.52	1.64	1.90					

MACON STATION ON OCMULGEE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 79, is at Macon, Georgia. The wire gage on the Macon, Dublin and Savannah Railroad bridge having been twice stolen in the spring of 1897, observations were taken on the Weather Bureau gage referred to the same datum, which is a vertical rod bolted to stone pier of the Georgia Railroad bridge. The observer is W. T. Bass. A bench mark on the top and upper end of the triangular casting at the foot of the seventh tie rod of the first span from the south of the former bridge is 28.84 feet above datum of gage. Measurements of discharge are made from the wagon bridge a short distance above. The velocity of the water is gentle, but not too slow for accurate measurements. The section is broken by one pier. The following measurements were made by B. M. Hall and Max Hall during 1897:

March 15, gage height, 16.75 feet; discharge, 25,535 second-feet.
May 4, gage height, 4.30 feet; discharge, 2,750 second-feet.
May 5, gage height, 3.50 feet; discharge, 2,275 second-feet.
May 18, gage height, 2.10 feet; discharge, 1,592 second-feet.
June 11, gage height, 2.85 feet; discharge, 2,111 second-feet.
June 12, gage height, 1.85 feet; discharge, 1,479 second-feet.
June 29, gage height, 0.90 foot; discharge, 1,005 second-feet.
September 23, gage height, —0.35 foot; discharge, 504 second-feet.
September 23, gage height, —0.35 foot; discharge, 497 second-feet.
November 7, gage height, 0.06 foot; discharge, 735 second-feet.
December 6, gage height, 1.20 feet; discharge, 1,356 second-feet.

Daily gage height, in feet, of Ocmulgee River at Macon, Georgia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.68	2.00	4.00	5.57	1.95	1.22	1.08	1.08	1.10	—0.50	—0.12	1.22
2	.63	5.00	3.70	9.75	1.90	1.18	.75	.84	1.25	— .45	+ .35	.70
3	.60	8.00	3.20	10.05	1.87	3.15	.65	.72	.68	— .50	.48	.60
4	.58	6.00	2.00	10.00	2.15	3.20	2.15	.40	.62	— .54	.35	.62
5	.56	6.00	4.00	15.12	2.23	3.12	2.30	.38	.35	— .61	.25	1.48
6	.54	8.00	3.00	15.15	2.47	3.10	3.80	.42	.28	— .68	.12	1.30
7	.52	6.50	11.60	12.60	3.00	3.00	3.12	1.40	.22	— .52	.10	1.12
8	.50	5.00	12.70	10.48	3.00	2.54	1.62	3.22	.12	— .55	.50	1.48
9	.49	4.75	7.50	10.00	2.91	2.32	1.28	1.10	— .07	— .55	.20	.60
10	.49	4.55	5.00	10.80	2.72	2.26	.90	.80	— .03	— .58	.20	.52
11	.51	5.00	4.80	7.80	2.57	2.18	3.10	1.60	— .10	+ .12	.30	.48
12	.49	13.50	6.00	6.40	2.45	2.08	3.33	2.00	— .50	.10	.60	.43
13	.48	12.75	17.30	5.00	3.05	2.04	1.50	1.02	— .20	.12	.30	.41
14	.53	7.00	18.00	4.70	3.15	2.01	.90	.70	— .12	.80	— .20	.90
15	.46	5.00	17.70	4.00	3.28	1.89	.30	.40	— .20	.30	— .10	1.46
16	.44	5.00	13.00	4.00	3.00	1.73	.50	.32	— .18	.10	— .18	1.22
17	.44	5.12	9.45	3.70	2.50	1.52	.22	.20	— .22	— .20	— .10	.40
18	1.15	3.00	8.25	3.50	2.22	1.45	.40	2.60	— .33	— .18	— .20	.58
19	1.50	2.75	8.20	3.20	2.09	1.37	1.48	2.28	1.60	— .20	— .20	.52
20	2.10	2.62	9.57	3.00	1.84	3.25	4.50	8.18	.20	— .02	— .10	.47
21	1.25	2.65	10.00	2.90	1.81	3.12	9.82	8.80	— .12	.00	— .08	.47
22	7.00	2.71	9.00	2.80	1.78	2.80	8.40	8.10	— .14	.20	— .13	.51
23	5.50	2.00	15.50	2.70	1.71	2.62	5.52	6.48	— .35	.18	— .10	.70
24	3.00	1.90	14.00	2.60	1.68	2.70	3.05	4.70	— .28	.10	— .50	.68
25	2.25	6.00	10.60	2.40	1.60	3.00	1.70	2.10	— .30	.05	— .20	1.02
26	2.00	10.50	8.35	2.30	1.56	3.11	1.11	1.40	— .28	.02	— .10	.89
27	3.00	7.02	7.10	2.22	1.53	2.50	1.32	1.08	— .25	— .12	+ .10	.89
28	3.12	5.00	6.40	2.16	1.50	1.00	3.22	.80	— .32	— .16	.25	1.42
29	1.50	.....	5.57	2.08	1.47	.90	2.10	.58	— .35	— .20	3.10	1.08
30	1.25	.....	5.21	2.00	1.36	1.50	1.76	.52	— .42	— .20	1.40	.75
31	1.20	.....	5.20	.....	1.28	.....	1.12	.40	.....	— .20	.....	.65

MOLENA STATION ON FLINT RIVER.

This station is located at the bridge of the Georgia Midland Division of the Southern Railway 2 miles southwest of Molena, Georgia. The wire gage is attached to the stringer of the bridge. The bench mark is the top of the dowstream iron girder under the cross-ties, 90 feet from the end of the bridge on the left side of the river, and its elevation is 30.65 above the gage datum. The channel is straight for so ne distance above and below the bridge. The right bank is low and liable to overflow, with a long trestle approach to the bridge. The left bank is not so liable to overflow, and on that side the trestle approach is shorter. The current is sluggish. There is one pier in mid-channel, but the section is better at the railroad bridge than at the wagon bridge below. The observer is J. A. Moore. The following measurements were made in 1897 by B. M. Hall and others:

May 21, gage height, 1.50 feet; discharge, 641 second-feet.
June 7, gage height, 1.75 feet; discharge, 707 second-feet.
June 23, gage height, 1.70 feet; discharge, 697 second-feet.
August 25, gage height, 3.30 feet; discharge, 2,843 second-feet.
November 8, gage height, 1.70 feet; discharge, 264 second-feet.
December 7, gage height, 2.10 feet; discharge, 588 second-feet.

At Woodbury, 3 miles below station:

May 21, gage height, 1.50 feet; discharge, 642 second-feet.

Daily gage height, in feet, of Flint River at Molena, Georgia, for 1897.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.40	1.45	1.90	1.15	1.60	2.15
2	.....	1.30	1.25	1.70	1.15	1.65	2.10
3	.....	1.20	1.15	1.40	1.20	1.75	1.95
4	.....	1.35	1.10	1.25	1.20	1.70	1.95
5	.....	2.65	1.05	1.15	1.15	1.70	2.15
6	.....	2.45	1.00	1.10	1.20	1.80	2.15
7	1.75	2.25	1.25	1.05	1.25	1.70	2.10
8	2.00	1.90	1.15	1.05	1.30	1.70	2.05
9	2.00	1.75	1.10	1.00	1.30	1.65	1.95
10	1.75	1.80	1.20	1.05	1.40	1.90	1.90
11	1.30	4.05	1.50	1.00	1.45	1.90	1.90
12	1.15	3.05	1.70	1.05	1.50	1.95	1.90
13	1.50	2.55	1.55	.95	1.50	1.85	1.90
14	1.60	2.05	1.45	1.00	1.75	1.80	2.00
15	1.60	1.50	1.35	1.10	1.70	1.75	2.10
16	2.00	1.35	1.25	1.15	1.70	1.80	2.10
17	1.60	1.25	1.20	1.10	1.60	1.90	2.00
18	1.50	1.20	1.70	1.20	1.50	1.95	2.00
19	1.40	1.15	2.25	1.10	1.35	1.85	1.95
20	1.70	2.25	2.80	1.00	1.50	1.70	1.90
21	2.20	2.80	2.80	1.05	1.50	1.75	1.90
22	2.40	3.55	3.45	1.10	1.45	1.80	2.00
23	1.70	2.55	3.70	1.05	1.50	1.90	2.10
24	2.25	2.15	3.60	1.00	1.50	1.90	2.10
25	1.70	1.80	3.05	1.10	1.45	1.90	2.00
26	1.45	1.55	2.20	1.15	1.45	1.80	2.00
27	1.35	1.65	1.65	1.05	1.40	1.80	2.10
28	1.25	2.25	1.50	1.10	1.45	1.95	2.10
29	1.20	2.10	1.40	1.05	1.50	2.10	2.10
30	1.10	2.05	1.30	1.10	1.70	2.20	2.00
31	.....	1.95	3.00	.....	1.55	.....	2.00

OAKDALE STATION ON CHATTAHOOCHEE RIVER.

This station described in the Eighteenth Annual Report, Part IV, page 85, is located at the Southern Railroad bridge, 1 mile above the mouth of Proctor Creek, at Oakdale, Georgia. The pulley and rod of the wire gage is attached to the lower guard rail on the second panel of the second span from the east. The length of the wire gage is 58.85 feet. The distance from the pulley to the zero of the rod is 2.20 feet. Bench mark 1, a railroad spike in corner of stone pier, toward river, downstream side, is 12.39 feet above datum. Bench mark 2, center of pulley, is 56.36 feet above datum. The observer is J. H. Lowry. The following discharge measurements were made by B. M. Hall and others during 1897:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Apr. 24	2.90	3,065	June 16	0.94	1,523	Sept. 17	—0.30	778
Apr. 27	2.70	2,703	June 28	.57	1,306	Oct. 2	— .50	659
May 22	1.65	2,055	July 20	12.9	15,617	Nov. 5	.46	1,194
May 25	1.50	2,014	Aug. 5	.84	1,276	Nov. 24	— .05	879
May 31	1.35	1,929	Aug. 27	.33	1,196	Dec. 6	2.65	2,426
May 31	1.35	2,003	Sept. 10	— .12	849	Dec. 28	1.70	1,926
June 9	1.44	1,991						

Daily gage height, in feet, of Chattahoochee River at Oakdale, Georgia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.20	3.10	2.00	2.90	4.10	1.00	0.50	0.85	0.50	—0.50	0.00	1.10
2	.20	4.50	1.80	4.30	3.20	1.00	.45	.80	.35	— .50	.35	.85
3	.20	4.90	1.80	5.55	2.80	1.15	.55	.90	.10	— .50	.35	1.20
4	.30	3.25	2.00	8.00	2.50	1.35	.55	.80	.20	— .45	.95	1.90
5	.40	3.70	1.90	11.80	2.40	1.15	1.15	.70	.10	— .50	.35	2.65
6	.40	4.10	9.00	17.25	2.25	1.05	.65	.65	.00	— .50	.30	2.60
7	.35	5.50	9.20	8.75	2.15	1.00	2.50	1.60	.00	— .50	.15	1.50
8	.35	5.00	5.50	5.70	2.05	.85	1.80	1.35	—.05	— .40	.15	1.10
9	.30	3.10	4.45	6.12	2.00	1.10	1.32	1.40	—.15	— .45	.10	.75
10	.30	2.40	4.05	5.30	1.95	1.00	2.45	1.20	—.15	— .45	.15	.60
11	.20	3.40	3.60	4.50	1.90	1.00	2.45	.95	—.20	+1.35	.10	.55
12	.20	4.00	6.40	4.05	1.90	.85	1.60	.80	—.20	1.50	.05	.50
13	.40	5.30	12.60	4.00	1.85	.75	1.20	.65	—.15	1.40	.00	.50
14	3.00	4.00	10.00	4.55	1.90	.65	.85	.50	—.20	— .35	—.05	1.75
15	3.70	2.60	8.40	4.05	2.35	.55	.60	.45	—.25	+ .15	—.10	1.80
16	2.80	2.60	6.80	4.00	1.85	.50	.50	.40	—.25	.00	—.05	1.90
17	2.40	2.40	5.45	3.50	1.70	1.55	4.20	2.90	—.30	— .05	+.10	1.65
18	4.00	2.10	6.10	2.20	1.50	1.00	2.45	1.25	—.30	— .15	—.05	1.15
19	4.60	1.90	5.80	3.05	1.45	1.05	12.00	.95	—.30	— .15	—.05	.65
20	5.50	2.50	5.55	3.00	1.35	.55	13.25	.65	—.35	.00	—.05	.75
21	7.50	2.50	5.00	2.80	1.35	1.35	10.30	.55	—.35	1.45	—.05	.95
22	6.85	2.90	4.30	2.75	1.40	.75	6.10	1.15	—.35	.85	—.05	1.95
23	3.90	5.10	4.50	2.70	1.40	.55	4.35	1.10	—.35	.15	—.05	2.95
24	3.20	4.50	4.00	2.70	1.35	.45	2.20	1.00	—.30	.00	—.10	1.75
25	2.00	3.60	3.90	2.65	1.30	.90	1.65	.60	—.25	.05	—.10	1.70
26	1.65	2.90	3.85	2.60	1.20	.55	2.85	.50	—.30	.05	—.10	2.25
27	.45	2.40	3.10	2.40	1.10	.45	2.30	.25	—.35	— .05	+.50	1.95
28	1.10	2.05	3.00	2.10	1.05	.30	1.35	.20	—.35	— .05	1.35	1.85
29	1.25	.....	2.75	2.00	1.00	1.00	1.20	.20	—.35	— .05	1.85	1.35
30	1.50	.....	2.70	2.20	1.05	.75	1.10	.15	—.40	— .10	1.50	2.05
31	2.00	.....	2.15	.....	1.10	.....	.95	1.65	.....	— .10	.....	.95

WEST POINT STATION ON CHATTAHOOCHEE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 90, is at the highway bridge in the city of West Point, Georgia, about 1,200 feet from the railroad passenger depot. The rod on the highway bridge is nailed to the floor of the downstream footway on the outside of the iron hand rail. The center of the 3-inch pulley is at gage height 25.38 feet and 7.9 feet from zero point of rod. The length of cable from bottom of weight to index is 33.46 feet. One bench mark on the highway bridge is the top of the first-floor beam from west end pier and is 24.01 feet above zero; the other is on the top of the second-floor beam from west end pier and is 24.19 feet above zero. The bottom is sandy and liable to change. The banks of the river at the ends of the bridge seldom, if ever, overflow, but the ground between the banks and the depot is lower and does overflow at high water. The observer is C. E. Melton. The following discharge measurements were made by B. M. Hall and Max Hall during 1897:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Jan. 23	6.66	11,921	June 19	2.59	2,934	Sept. 22	1.20	985
Apr. 26	3.70	5,448	July 8	3.03	3,470	Nov. 9	1.71	1,345
May 4	4.13	6,230	July 23	5.01	7,853	Nov. 23	1.60	1,322
May 19	3.00	3,557	Aug. 14	2.12	1,915	Dec. 17	3.14	3,989
June 5	2.90	3,253	Sept. 4	1.80	1,690			

Daily gage height, in feet, of Chattahoochee River at West Point, Georgia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.90	3.15	3.65	4.00	3.90	2.65	1.90	2.90	1.80	1.10	1.30	2.50
2	1.90	4.40	3.60	4.00	4.00	2.70	1.90	3.00	1.70	1.10	1.30	2.50
3	1.90	7.00	3.50	3.95	3.80	2.80	2.00	3.20	1.65	1.05	1.30	2.50
4	1.95	7.40	3.50	4.40	3.75	2.85	2.30	2.80	1.65	1.05	1.50	2.40
5	2.00	7.10	3.60	8.50	3.65	2.90	3.00	2.80	1.60	1.00	2.30	2.60
6	2.00	6.00	4.10	10.20	3.60	2.95	3.50	2.50	1.60	1.00	2.00	2.75
7	2.00	6.00	10.95	11.00	3.60	2.80	2.50	2.40	1.50	1.00	1.80	2.85
8	1.95	5.20	9.30	10.50	3.60	2.70	3.00	2.20	1.50	0.95	1.65	2.60
9	1.95	5.00	7.10	8.00	3.55	2.60	3.00	2.00	1.40	0.95	1.70	2.60
10	1.90	4.70	5.50	7.10	3.50	2.60	2.90	1.90	1.40	0.95	1.90	2.50
11	1.90	4.90	5.30	6.50	3.50	2.65	2.90	2.90	1.40	1.15	1.90	2.40
12	1.95	7.12	6.20	6.30	3.55	2.65	2.80	3.00	1.35	1.50	1.70	2.40
13	1.95	6.50	10.70	6.00	3.75	2.60	2.40	2.70	1.35	3.00	1.70	2.50
14	2.10	6.10	14.10	5.80	3.60	2.50	2.20	2.30	1.30	2.90	1.60	4.30
15	2.20	4.70	12.90	5.70	3.40	2.45	2.00	2.25	1.30	2.50	1.60	3.75
16	4.00	4.65	11.00	5.50	3.20	2.40	1.80	2.00	1.30	1.90	1.60	3.50
17	4.05	4.60	10.90	5.30	3.10	2.50	1.90	2.95	1.25	1.75	1.50	3.10
18	3.35	4.50	10.00	5.00	3.00	2.90	2.90	3.50	1.25	1.65	1.50	3.05
19	3.30	4.30	9.00	4.50	3.00	2.70	3.00	4.00	1.20	1.60	1.55	3.10
20	5.40	4.35	8.50	4.20	2.90	2.60	9.00	4.50	1.20	1.40	1.40	3.90
21	8.20	4.35	8.30	4.20	2.85	2.55	11.40	6.20	1.20	1.50	1.30	4.00
22	7.30	4.40	8.10	4.10	2.80	2.55	8.00	8.10	1.20	1.60	1.20	3.80
23	6.50	4.85	8.00	4.00	2.75	2.50	5.40	7.00	1.20	1.40	1.10	3.70
24	4.80	5.60	8.50	3.80	2.70	2.50	4.40	6.10	1.20	1.40	1.05	3.70
25	3.70	5.50	7.60	3.85	2.70	2.50	4.20	3.50	1.15	1.30	1.05	3.65
26	3.50	4.00	5.00	3.70	2.70	2.60	4.10	2.80	1.15	1.30	1.10	3.60
27	3.20	3.90	4.95	3.65	2.70	2.30	4.00	2.40	1.15	1.20	1.90	3.50
28	3.00	3.80	4.70	3.60	2.65	2.15	3.60	2.10	1.10	1.20	2.65	3.20
29	3.00	.....	4.50	3.60	2.65	2.00	3.50	2.10	1.10	1.40	2.60	2.80
30	2.95	.....	4.30	3.80	2.65	1.90	3.00	1.90	1.10	1.40	2.50	2.60
31	3.20	.....	4.00	.....	2.65	.....	2.80	1.90	.....	1.30	.....	2.50

CANTON STATION ON ETOWAH RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 94, is one-half mile above the mouth of Canton Creek, and is located at the iron highway bridge over Etowah River about 1,000 feet north of and upstream from the Atlanta, Knoxville and Northern Railroad depot at Canton, Georgia. The United States Weather Bureau gage rod is used. The observer is J. A. Low. The bench mark is on the left-bank pier. The iron bridge rests on four pieces of railroad track iron, forming a cap. Measuring from the end toward the river on one of these on the upstream side of the bridge, its top is 23.3 feet above the datum of the gage. Up to 3 feet gage height the river is only 116 feet wide, and flows between the piers on its lower banks. Up to about 14 feet it is confined between its upper banks, which are the abutments at outer end of approaches. Above this stage it begins to overflow the bottom lands. The initial point is the top of right-bank pier, at its edge toward the river. The following discharge measurements were made by B. M. Hall and Max Hall during 1897:

March 17, gage height, 2.60 feet; discharge, 2,656 second-feet.
May 5, gage height, 0.75 foot; discharge, 1,264 second-feet.
June 16, gage height, 1.27 feet; discharge, 1,632 second-feet.
August 28, gage height, —0.30 foot; discharge, 449 second-feet.
September 21, gage height, —0.60 foot; discharge, 284 second-feet.
November 12, gage height, 0.23 foot; discharge, 346 second-feet.
December 13, gage height, 0.33 foot; discharge, 514 second-feet.

Daily gage height, in feet, of Etowah River at Canton, Georgia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	—0.10	0.60	0.80	1.60	2.00	0.10	0.00	0.20	0.80	—0.70	0.20	0.60
2	—.10	2.20	.60	2.00	1.80	.10	.00	.00	.00	—.70	.80	.60
3	—.10	1.00	.60	2.00	1.80	.70	.00	.00	—.30	—.70	.80	.60
4	—.10	.80	.60	2.60	1.60	.50	.00	.00	—.40	—.50	.60	.60
5	—.10	.80	0.60	11.20	.70	.50	.00	.00	—.40	—.40	.50	2.00
6	—.10	.90	3.60	5.00	.70	.50	.00	.60	—.50	—.30	.50	1.00
7	—.10	.80	4.00	3.00	.70	.40	.40	.80	—.50	—.30	.30	.90
8	—.10	.80	2.00	2.00	.60	.40	.40	.80	—.50	—.40	.30	.80
9	—.10	.80	1.80	3.00	.60	.30	.40	.60	—.60	—.40	.30	.80
10	—.10	.80	1.80	2.60	.50	.30	.30	.60	—.60	—.40	.20	.80
11	—.10	.80	1.80	2.40	.50	.20	.30	.60	—.60	+1.20	.20	.80
12	—.10	.80	2.80	2.20	.50	.10	.20	.40	—.60	1.00	.20	.60
13	—.10	1.80	7.20	2.00	.50	.10	.20	.40	—.60	.80	.20	.80
14	2.20	1.00	6.80	2.00	.40	.10	.20	.20	—.60	.80	.20	.90
15	1.80	.80	4.00	2.00	.40	.00	.10	.20	—.60	.60	.20	.90
16	.90	.80	3.60	1.80	.40	3.00	.10	.20	—.60	.60	.20	.80
17	.50	.70	2.60	1.80	.40	1.00	.90	1.00	—.60	.60	.20	.70
18	2.00	.60	2.40	1.40	.40	.80	.90	1.00	—.60	.40	.20	.70
19	1.60	.60	2.00	1.40	.40	.60	1.00	.80	—.60	.40	.10	.80
20	3.60	.60	2.80	1.20	.40	.40	2.00	.60	—.60	.60	.10	.80
21	3.00	.80	2.00	1.20	.30	.40	7.10	.40	—.60	.40	.20	.90
22	2.00	.80	1.00	1.00	.30	.30	2.50	.20	—.60	.40	.20	1.00
23	1.00	1.60	1.80	1.00	.20	.30	1.00	.00	—.50	.40	.20	.90
24	.80	1.00	1.80	1.00	.10	.30	.80	.00	—.50	.40	.20	.80
25	.70	1.00	1.60	1.00	.10	.30	.80	.00	—.50	.40	.80	.80
26	.70	.80	1.60	.80	.10	.20	.60	—.10	—.80	.40	.60	.80
27	.70	.80	1.40	.80	.10	.10	.60	—.20	—.60	.30	.60	.70
28	.60	.80	1.20	.80	.10	.10	.50	—.30	—.50	.30	.60	.60
29	.60	.....	1.20	1.00	.10	.10	.50	—.40	—.60	.30	.80	.60
30	.60	.....	1.20	1.00	.10	.10	.40	—.40	—.60	.30	.60	.60
31	.60	.....	1.20	.....	.10	.....	.20	+1.00	.....	.20	.....	.50

CARTERS STATION ON COOSAWATTEE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 96, is at the iron highway bridge at Carters, Murray County, Georgia, about 20 miles northeast of Calhoun, the most convenient railroad station. The current is not uniform, being broken by a gravel bar above, but is a fairly good section for measurement. The bed is gravel and not apt to change. The banks are high, but are sometimes overflowed. The rod of the gage is nailed to the outside of the guard timber on downstream side of the bridge. Center of 3-inch pulley is 20 feet from initial point and is 32.05 feet above datum. The zero point of rod is 5 feet from center of pulley. The length of wire cable from bottom of weight to index marker is 37.24 feet. The top of the cylindrical iron pier at the right-bank downstream corner of bridge is 30.35 feet above gage datum. The observer is Col. S. M. Carter. The following measurements were made by Max Hall and others during 1897:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. feet.*		*Feet.*	*Sec. feet.*		*Feet.*	*Sec. feet.*
May 22...	2.10	815	June 28....	1.33	474	Nov. 15...	0.77	243
May 24...	1.95	771	July 15....	1.50	545	Nov. 24...	.75	263
May 26...	1.88	712	July 22....	2.41	1,079	Dec. 14...	2.71	1,118
May 28...	1.85	698	Sept. 17...	.70	251	Dec. 22...	3.54	1,661
June 1....	1.90	724	Sept. 27...	.60	216			

Daily gage height, in feet, of Coosawattee River at Carters, Georgia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.30	1.40	2.05	4.05	4.00	1.90	1.40	1.35	1.00	0.60	0.80	0.75
2	1.25	4.00	1.95	4.10	3.25	1.90	1.40	1.35	1.00	.60	.80	.75
3	1.25	3.00	1.85	5.00	2.75	1.90	1.30	1.30	.95	.60	1.50	.90
4	1.25	2.15	1.85	9.00	2.50	2.20	1.30	1.30	.95	.60	1.00	2.20
5	1.20	2.40	1.80	15.00	2.40	2.00	1.30	1.40	.90	.55	.70	3.50
6	1.20	2.40	9.00	4.50	2.35	1.90	1.40	2.50	.90	.55	.60	1.90
7	1.20	2.50	5.10	4.00	2.30	1.80	1.70	2.00	.90	.55	.60	1.80
8	1.20	2.55	4.00	3.50	2.20	1.80	1.60	1.80	.80	.55	.70	1.80
9	1.15	2.55	3.50	5.50	2.15	1.70	1.60	1.60	.75	.55	.70	1.50
10	1.15	2.50	3.50	5.00	2.20	1.60	1.60	1.60	.75	.55	.80	1.50
11	1.15	2.50	3.60	4.50	2.50	1.60	1.70	1.50	.70	.55	.80	2.10
12	1.20	2.70	21.15	4.30	3.50	1.60	1.50	1.40	.70	2.50	.70	1.80
13	4.15	2.50	11.50	4.00	2.50	1.50	1.40	1.30	.70	1.10	.70	2.00
14	2.20	2.50	13.62	3.50	2.50	1.50	1.40	1.20	.70	1.00	.70	2.70
15	2.10	2.10	10.00	4.50	2.40	1.50	1.50	1.10	.70	1.00	.60	2.50
16	2.15	2.10	8.00	3.50	2.30	2.70	1.50	1.10	.65	.90	.60	2.40
17	2.20	2.05	5.50	3.30	2.30	1.80	1.50	1.10	.70	.80	.70	2.40
18	2.00	2.00	5.00	3.25	2.30	1.60	1.70	1.10	.65	.70	.70	2.60
19	2.00	2.00	6.00	3.20	2.20	1.50	9.90	1.05	.60	.70	.70	2.70
20	3.15	2.00	6.00	3.10	2.20	1.50	3.50	1.05	.60	1.45	.70	2.50
21	4.10	2.05	5.10	3.00	2.10	1.50	2.40	1.05	.60	1.40	.65	3.00
22	2.15	2.10	5.00	3.95	2.10	1.40	3.00	1.05	.60	1.10	.65	3.10
23	2.10	7.00	4.80	3.95	2.00	1.40	2.00	1.00	.60	.80	.65	2.90
24	2.00	3.50	4.50	3.90	2.00	1.50	1.50	1.00	.60	.80	.70	2.80
25	2.00	2.50	4.00	3.80	1.90	1.40	1.50	.90	.60	.70	.70	2.50
26	1.90	2.40	3.75	3.70	1.90	1.40	1.90	.90	.60	.70	.70	2.20
27	1.70	2.30	3.50	3.65	1.80	1.40	1.60	.80	.60	.60	.70	2.00
28	1.50	2.20	3.35	3.60	1.80	1.40	1.50	.80	.60	.60	.70	1.80
29	1.40	.....	3.25	3.50	1.80	2.50	1.40	.90	.60	.60	.75	1.50
30	1.30	.....	3.10	3.50	2.50	1.50	1.40	3.50	.65	.60	.75	1.40
31	1.20	.....	3.00	.....	2.00	.....	1.40	1.50	.....	.55	.....	1.30

RESACA STATION ON OOSTANAULA RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 98, is at the iron railroad bridge of the Western and Atlantic Railroad, in the town of Resaca, Georgia, 1,000 feet from the depot. The river bed is probably soft and liable to change. The wire gage is adjusted to the same datum as the Weather Bureau gage at this point. The initial point is the first pin of bottom link cord at right-bank end of bridge, downstream side. The rod of the wire gage is nailed to the outside of the guard rail on the downstream side. The center of the 3 inch pulley is on the downstream side of the bridge 61.50 feet from initial point, and at 40.20 feet gage height. The end or zero point of the rod is 3 feet from the center of the pulley. The length from bottom of weight to index of gage cable is 43.40 feet. The first bench mark is on the top of capstone of center pier at 36.12 feet gage height. The second is the top of cross-tie near center at 40.12 feet gage height. The observer is S. M. Barnett, railroad agent at depot, who is also the observer for the Weather Bureau. The following discharge measurements were made by Olin P. Hall and Max Hall during 1897:

May 25, gage height, 3.48 feet; discharge, 1,535 second-feet.
May 29, gage height, 3.26 feet; discharge, 1,389 second-feet.
June 23, gage height, 2.44 feet; discharge, 972 second-feet.
September 23, gage height, 1.20 feet; discharge, 406 second-feet.
November 14, gage height, 1.46 feet; discharge, 510 second-feet.
December 24, gage height, 7.10 feet; discharge, 4,642 second-feet.
December 30, gage height, 3.42 feet; discharge, 1,630 second-feet.

Daily gage height, in feet, of Oostanaula River at Resaca, Georgia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.20	3.80	4.60	7.30	5.40	4.25	2.60	2.45	2.30	1.00	1.35	1.85
2	2.20	13.90	4.40	11.40	5.05	3.50	2.25	2.30	1.90	1.05	2.05	1.65
3	2.20	14.00	4.20	12.40	4.60	3.50	2.20	3.00	1.90	1.05	2.30	2.00
4	2.20	13.20	4.30	12.50	4.40	3.65	2.15	2.40	1.80	.95	2.10	4.65
5	3.00	8.70	5.90	18.50	4.25	3.35	2.20	2.50	1.80	.95	1.90	5.10
6	3.05	6.20	10.50	20.30	4.10	3.15	2.55	3.15	1.60	1.05	1.75	5.70
7	2.75	7.30	18.00	19.60	4.00	3.00	6.20	4.00	1.50	1.10	1.65	4.30
8	2.50	7.60	18.80	16.30	3.95	2.90	3.60	3.45	1.45	1.05	1.55	3.10
9	2.40	7.00	19.00	10.10	3.85	3.00	2.80	2.85	1.40	1.05	1.55	2.60
10	2.30	6.00	16.20	10.40	3.85	3.15	2.80	2.50	1.40	1.05	1.55	2.35
11	2.25	5.80	10.70	8.60	3.95	2.90	3.25	3.20	1.40	1.10	1.55	2.20
12	2.25	8.60	16.50	7.60	4.90	2.75	3.30	2.75	1.40	2.05	1.50	2.20
13	2.25	9.80	21.70	6.80	5.45	2.70	2.90	2.50	1.35	3.00	1.45	2.10
14	5.45	7.70	21.70	6.40	8.45	2.60	2.65	2.15	1.30	1.80	1.45	4.15
15	7.50	6.40	24.60	6.80	8.75	2.55	2.30	2.10	1.30	1.60	1.45	5.30
16	5.10	5.70	26.00	8.20	5.70	2.60	2.15	2.10	1.30	1.45	1.40	4.45
17	4.10	5.40	25.30	7.00	4.70	2.70	3.10	2.55	1.30	1.35	1.40	3.40
18	5.40	4.70	23.80	6.20	4.40	2.90	2.90	3.00	1.40	1.20	1.45	2.90
19	5.20	4.50	21.30	5.80	4.10	2.75	3.40	2.20	1.25	1.15	1.45	2.75
20	4.40	4.50	18.90	5.50	3.95	2.60	11.80	2.10	1.20	2.15	1.40	5.25
21	9.60	5.00	18.20	5.30	3.85	2.60	7.85	2.00	1.15	2.05	1.40	6.20
22	8.70	4.60	18.40	5.10	3.80	2.45	9.00	2.20	1.15	2.00	1.40	8.45
23	6.10	11.40	17.50	4.90	3.75	2.35	7.20	2.60	1.15	1.80	1.40	9.25
24	5.00	12.00	12.70	4.80	3.60	2.35	4.20	2.50	1.15	1.75	1.45	7.50
25	4.40	10.60	8.40	4.80	3.50	2.45	3.25	2.20	1.15	1.50	1.40	4.95
26	4.00	6.70	7.60	4.70	3.35	2.45	4.05	2.05	1.15	1.40	1.40	4.45
27	3.70	5.70	6.70	4.70	3.30	2.30	4.40	2.00	1.15	1.35	1.55	4.90
28	3.40	5.10	6.60	4.60	3.25	2.25	3.90	1.85	1.10	1.35	1.60	4.25
29	2.70	.....	6.00	4.40	3.25	3.50	3.20	1.75	1.20	1.35	1.75	3.75
30	3.10	.....	6.00	4.30	3.15	2.90	2.80	1.70	1.00	1.30	1.75	3.40
31	3.50	.....	6.00	.....	3.50	.....	2.55	1.85	.....	1.30	.....	3.20

RIVERSIDE STATION ON COOSA RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 99, is at the bridge of the Southern Railway across the Coosa River near Riverside, Alabama. The observer is J. W. Foster, who is employed at a large sawmill about 300 feet distant. The center of the 3-inch pulley is 5 feet east of zero of rod, and is 33.15 feet above gage datum. The length of wire cable from bottom of weight to index is 38.35 feet. The first bench mark is the top of capstone on the large circular center pier of turn span. It is 26.80 feet above datum of gage at downstream side of pier. The top of the first iron floor beam on stationary part east of the draw, near gage, downstream end, is 31.13 feet above gage datum. The following discharge measurements were made by B. M. Hall and Max Hall during 1897:

March 31, gage height, 4.53 feet; discharge, 12,515 second-feet.
June 17, gage height, 1.54 feet; discharge, 3,747 second-feet.
July 21, gage height, 5.55 feet; discharge, 16,925 second-feet.
August 20, gage height, 2.58 feet; discharge, 6,174 second-feet.
November 29, gage height, 0.80 foot; discharge, 1,854 second-feet.

LOCK NO. 4 AND LOCK NO. 5.

The station at Lock No. 4, described in Water Supply and Irrigation Paper No. 11, page 31, is located 3 miles above Riverside, Alabama. The first section of the vertical gage rod is fastened to the lower end of the cofferdam, 500 feet below the dam on the river. The second section is fastened to a sycamore tree 150 feet below rod 1. Zero of rod is 477.30 feet above the Mobile datum. The bench mark is a brass point in stone post 1,000 feet up river from lower gage, and is 510.55 feet above Mobile datum.

The station at Lock No. 5, described in the Eighteenth Annual Report, Part IV, page 101, is located one-half mile above the Birmingham and Atlantic Railroad crossing and about 20 miles below the gaging station at Riverside, Alabama. The gage is vertical, in two sections, fastened to trees, immediately above the landing at Collin's ferry. The zero of the gage is 460.37 feet above Mobile datum. Bench mark 1 is on the oak tree, to which one section of the rod is fastened, and is 471.80 feet above Mobile datum. Bench mark 2 is center of iron plate at top of cylindrical pier at right bank, upstream side of railroad bridge below, and it is at an elevation of 493.91 feet, Mobile datum. River height observations were continued at these stations in 1897 under the direction of the United States Engineer Corps.

Daily gage height, in feet, of Coosa River at Riverside, Alabama, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.10	2.00	5.00	4.30	3.40	1.90	1.45	2.00	1.20	0.50	0.70	0.80
2	1.10	2.50	4.50	4.45	3.10	1.90	1.45	1.80	1.10	.50	.70	.90
3	1.10	5 35	4.25	5.20	3.05	1.90	1.40	1.60	1.30	.50	.70	.95
4	1.10	7.35	3.90	7.00	3.60	1.85	1.40	1.50	1.60	.50	.65	1.20
5	1.10	7.70	4.20	8.60	3.20	1.85	1.45	1.45	1.30	.45	.80	2.50
6	1.20	7.90	5.80	9.50	3.00	1.80	1.50	1.40	1.20	.45	1.05	3.00
7	1.25	9.00	11.40	10.50	3.80	1.90	1.50	1.50	1.10	.45	1.15	2.90
8	1.30	7.70	13.30	11.15	3.70	2.15	2.40	1.50	1.00	.45	1.10	2.40
9	1.35	6.40	12.55	12.15	2.65	2.10	2.30	1.60	.90	.45	1.00	2.15
10	1.35	5.90	12.65	11.90	2.60	1.90	2.05	1.70	.85	.45	.95	2.00
11	1.35	5.20	12.70	10.70	2.50	1.90	2.50	1.70	.80	.40	.85	1.70
12	1.30	7.35	12.80	9.10	2.55	2.00	2.70	2.00	.80	.40	.85	1.60
13	1.40	8.30	13.45	7.30	2.65	1.90	2.50	2.50	.75	.45	.85	1.60
14	2.00	8.20	14.80	6.05	2.10	1.85	2.00	2.30	.75	.45	.85	2.00
15	3.50	7.50	14.60	5.60	3.90	1.60	1.80	2.00	.80	1.45	.80	2.50
16	4.00	6.60	14.80	5.30	4.00	1.70	1.70	1.80	.85	1.65	.75	3.00
17	4.90	5.70	14.70	5.60	4.00	1.50	1.80	1.60	.85	1.40	.70	3.30
18	5.35	5.00	14.70	5.40	3.60	1.60	1.95	1.50	.80	1.35	.70	3.15
19	5.00	4.50	14.50	5.00	3.20	1.90	2.00	1.90	.80	1.20	.70	2.65
20	4.80	4.00	15.30	4.60	3.00	2.00	3.00	2.60	.75	1.00	.65	2.10
21	6.50	4.60	14.90	4.30	2.70	1.80	5.20	2.00	.75	.90	.65	2.20
22	7.00	4.65	14.70	4.00	2.35	1.70	6.40	1.70	.70	.85	.65	2.80
23	7.35	6.00	14.50	3.80	2.30	1.60	8.00	1.60	.70	.80	.65	4.20
24	7.00	7.90	13.70	3.60	2.25	1.55	6.20	1.70	.70	.70	.65	4.85
25	5.40	9.00	12.20	3.40	2.25	1.50	4.50	1.75	.65	.80	.65	4.95
26	4.70	9.00	10.60	3.30	2.15	1.45	4.00	1.60	.65	.75	.65	4.55
27	3.80	8.00	8.50	3.25	2.05	1.45	3.00	1.60	.60	.60	.65	3.85
28	3.00	6.20	6.50	2.20	2.00	1.40	2.60	1.50	.55	.65	.65	3.20
29	2.70	.....	5.30	3.10	2.00	1.45	2.50	1.40	.55	.80	.70	2.95
30	2.50	.....	4.90	3.20	1.95	1.45	3.00	1.35	.55	.75	.75	2.85
31	2.20	.....	4.60	.....	1.90	.....	2.60	1.30	.....	.70	.....	2.50

Daily gage height, in feet, of Coosa River at Lock No. 4, Alabama, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.8	2.0	5.8	5.1	3.4	1.9	1.1	1.9	0.8	0.1	0.3	0.4
2	.8	2.8	4.9	5.6	3.3	1.9	1.1	1.6	.7	.1	.4	.6
3	.8	6.2	4.4	7.6	3.9	1.9	1.4	1.5	.7	.1	.3	.9
4	1.0	8.8	4.4	8.2	4.6	2.1	1.3	1.3	.8	.1	.3	1.2
5	.9	9.3	5.5	9.9	3.4	2.1	1.2	1.2	1.0	.0	.3	1.6
6	.9	9.7	6.5	11.0	3.2	2.4	1.3	1.4	.8	.0	.9	2.6
7	.9	10.2	13.0	12.0	3.0	2.3	1.8	1.3	.7	— .1	.9	.....
8	1.0	9.2	14.8	12.7	2.9	2.0	2.5	1.2	.6	— .2	.8	3.7
9	1.2	7.5	15.1	13.8	2.8	1.8	2.1	1.5	.5	— .2	.7	3.1
10	1.2	6.7	14.5	13.7	2.7	1.7	2.4	2.0	.4	— .2	.6	2.4
11	1.0	6.8	14.6	12.3	2.6	1.6	2.5	2.1	.4	.0	.5	2.0
12	.9	8.6	15.0	10.0	2.6	1.7	3.0	2.1	.4	.0	.4	1.4
13	.8	9.7	15.5	8.5	3.0	1.7	2.2	2.6	.4	.0	.4	1.1
14	1.0	9.7	15.9	7.5	3.5	1.6	2.2	2.1	.4	.0	.4	1.6
15	2.3	9.0	17.0	6.7	4.5	1.5	2.2	1.8	.4	1.0	.4	1.8
16	4.3	8.0	16.8	6.4	4.5	1.4	1.6	1.5	.3	1.6	.4	2.6
17	5.7	6.6	17.0	6.4	4.7	1.3	1.6	1.3	.3	1.2	.3	3.4
18	6.2	5.0	17.0	6.2	4.5	1.4	1.9	1.5	.3	.7	.3	3.3
19	6.0	5.0	16.9	6.0	3.6	1.8	3.8	1.5	.3	.5	.3	2.8
20	5.5	4.5	17.9	5.2	3.0	2.4	5.5	2.0	.3	.4	.3	2.6
21	7.6	5.2	17.1	4.8	2.7	1.8	6.0	2.4	.2	.3	.3	2.1
22	8.2	5.8	16.9	4.0	2.5	1.5	7.5	1.6	.2	.3	.3	3.1
23	8.7	7.2	16.7	4.2	2.4	1.3	8.9	1.5	.1	.4	.3	4.8
24	8.3	9.5	15.6	4.0	2.3	1.3	7.4	1.4	.1	.4	.3	5.7
25	6.5	10.1	13.8	3.8	2.2	1.4	5.3	1.6	.1	.4	.3	5.7
26	4.8	10.2	11.8	3.6	2.2	1.2	3.9	1.6	.1	.6	.3	5.3
27	3.9	9.3	10.0	3.6	2.1	1.1	2.9	1.6	.1	.5	.3	4.4
28	3.4	7.5	7.5	3.5	1.9	1.1	2.4	1.3	.1	.4	.3	3.7
29	2.9	.....	6.3	3.4	1.9	1.3	3.0	1.1	.1	.3	.4	3.3
30	2.6	.....	5.6	3.7	1.8	1.3	2.9	1.0	.1	.3	.4	3.0
31	2.4	.....	5.2	.....	1.8	.....	2.4	.9	.....	.3	.....	2.9

Daily gage height, in feet, of Coosa River at Lock No. 5, Alabama, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.2	0.9	4.6	2.9	1.7	0.7	0.3	0.8	0.2	—0.3	—0.1	—0.1
2	.2	1.2	3.6	3.2	1.6	.7	.3	.6	.1	— .3	— .1	.1
3	.2	3.1	2.2	4.5	1.9	.7	.3	.5	.1	— .3	— .1	.2
4	.2	5.2	2.9	5.2	2.0	.8	.5	.5	.4	— .3	— .1	.4
5	.2	5.2	3.1	6.8	1.9	.8	.4	.4	.4	— .3	— .1	.6
6	.2	5.8	3.7	7.6	1.5	1.0	.4	.4	.2	— .3	+ .1	1.0
7	.2	7.1	9.4	8.5	1.4	1.0	.6	.3	.1	— .3	.1	1.5
8	.3	6.0	11.1	9.0	1.3	.8	1.1	.4	.0	— .3	.1	1.5
9	.4	4.7	11.2	10.0	1.3	.7	.9	.6	.0	— .3	.1	1.4
10	.4	4.0	10.6	9.9	1.2	.6	.9	.8	— .1	— .3	.1	1.0
11	.3	3.6	10.8	8.9	1.1	.6	1.1	.9	— .1	— .3	.1	.8
12	.3	5.4	11.2	7.8	1.1	.6	1.4	.8	— .1	— .3	.1	.6
13	.2	6.4	12.2	6.6	1.3	.6	1.0	1.1	— .1	— .3	.1	.5
14	.2	6.4	12.4	4.4	1.6	.6	.9	.9	— .1	— .3	— .2	.7
15	.9	5.8	13.1	4.0	2.2	.6	.9	.7	— .1	+ .1	— .2	.8
16	.9	5.0	13.0	3.9	2.3	.5	.7	.6	— .1	.5	— .2	1.1
17	2.8	3.0	12.9	3.8	2.5	.5	.7	.5	— .1	.3	— .2	1.5
18	3.5	3.1	12.7	3.4	2.3	.5	.7	.6	— .2	.2	— .2	1.7
19	3.3	2.6	12.5	3.0	1.8	.5	1.6	.9	— .3	.1	— .2	1.2
20	3.0	2.3	13.2	2.8	1.3	1.0	3.0	1.3	— .3	— .1	— .2	.9
21	4.4	2.4	12.8	2.4	1.2	.7	3.3	1.0	— .3	— .1	— .2	.8
22	5.1	2.5	12.6	2.3	1.1	.6	4.6	.8	— .3	— .1	— .2	.8
23	5.3	4.1	12.6	2.2	1.1	.5	5.9	.6	— .3	— .1	— .2	2.4
24	5.1	6.0	11.7	2.0	1.0	.4	4.5	.5	— .3	+ .1	— .2	3.5
25	3.8	7.3	10.3	1.9	.9	.4	3.0	.5	— .3	.1	— .2	3.5
26	2.5	7.3	8.7	1.8	.9	.4	2.0	.5	— .3	.1	— .2	2.8
27	1.9	6.1	6.8	1.7	.8	.4	1.4	.5	— .3	.1	— .2	2.3
28	1.5	6.1	4.7	1.7	.7	.4	1.0	.4	— .3	.1	— .1	1.6
29	1.3	.....	3.7	1.6	.7	.4	1.3	.4	— .3	— .1	— .1	1.5
30	1.2	.....	3.3	1.7	.7	.4	1.5	.3	— .3	— .1	.....	1.4
31	1.0	.....	3.0	.....	.7	.....	1.0	.2	.....	— .1	.....	1.2

WETUMPKA STATION ON COOSA RIVER.

This station is located at gage No. 1, 3 miles above Wetumpka, Alabama. The vertical rod is in two sections of 2 by 8 timbers. Rod 1 is attached to a crib on right bank at foot of old sawmill slide. Rod 2 is attached to a tree on right bank about 150 feet upstream from rod 1. Zero of gage is 172.40 feet above mean low tide at Mobile, Alabama. The bench mark is on a black walnut tree on right bank about 250 feet upstream from gage rod No. 2; elevation, 213.88 feet, Mobile datum. It was established November 5, 1889, by the United States Engineer Corps, who have maintained daily gage readings since that date. A copy of these readings has kindly been furnished by Capt. Philip M. Price, U. S. A., and are on file in this office. The following discharge measurements were made by Charles Firth, United States assistant engineer. They were begun in December, 1890, and continued through the high water of February and March, 1891:

Measurement.	Gage height.	Discharge.	Measurement.	Gage height.	Discharge.	Measurement.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
No. 1....	2.2	8,033	No. 16...	9.5	38,116	No. 31...	18.6	73,380
2....	2.5	8,598	17...	10.0	38,414	32...	19.5	79,011
3....	3.2	10,126	18...	10.7	47,530	33...	20.0	85,549
4....	4.7	15,426	19...	10.8	43,608	34...	21.0	73,159
5....	4.9	16,569	20...	11.0	46,347	35...	21.7	85,794
6....	5.5	18,835	21...	11.2	47,923	36...	22.0	80,182
7....	6.1	21,750	22...	12.6	53,690	37...	23.0	84,688
8....	6.2	22,243	23...	13.2	52,104	38...	23.4	109,041
9....	6.6	25,198	24...	13.4	58,414	39...	25.4	93,876
10....	6.7	24,168	25...	13.8	56,357	40...	25.4	94,213
11....	7.3	26,638	26...	14.2	65,439	41...	27.0	103,255
12....	7.7	29,210	27...	15.0	56,864	42...	27.3	118,407
13....	8.2	31,620	28...	16.5	67,276	43...	28.5	126,313
14....	8.5	32,174	29...	17.2	72,907			
15....	9.2	36,722	30...	17.7	70,793			

A rating table has been made based on these measurements, but it will not be applied to the gage heights for 1896 and 1897 until it can be verified by future discharge measurements.

Daily gage height, in feet, of Coosa River at Wetumpka, Alabama, for 1896.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.2	4.4	3.4	3.7	4.8	1.6	1.0	1.2	0.8	—0.1	0.4	1.2
2	3.6	4.0	3.4	4.4	4.9	1.5	.9	1.2	.6	—.2	.2	1.6
3	3.7	3.8	3.4	4.9	5.3	1.8	.8	1.2	.5	—.3	.4	2.9
4	3.6	3.6	3.2	6.1	4.1	2.2	.8	1.0	.5	2.4	.6	3.5
5	3.4	4.6	3.1	7.5	5.0	2.0	.9	1.2	.4	2.1	1.0	4.1
6	2.9	7.3	3.0	7.0	3.6	1.8	1.0	1.4	.3	2.0	1.2	3.3
7	1.5	9.8	5.0	6.5	3.6	2.2	1.3	1.4	.2	1.4	.5	2.6
8	2.8	12.2	4.9	5.8	3.3	2.0	1.6	1.3	.0	.8	.5	2.1
9	2.8	15.2	4.2	4.6	3.0	2.5	1.7	1.2	.0	.5	.4	2.0
10	2.5	15.1	4.0	4.1	2.5	3.5	4.3	1.0	.0	.2	2.2	2.0
11	2.2	14.0	4.4	3.7	2.4	3.4	5.2	.8	.0	.1	1.7	1.8
12	2.2	12.2	6.1	3.5	2.1	3.0	6.2	.8	.0	.1	1.9	1.6
13	2.4	11.7	6.9	3.3	2.0	2.5	5.9	.6	—.1	.0	4.9	1.4
14	2.6	9.0	6.7	3.3	1.8	2.0	4.4	.6	—.1	.0	2.6	1.4
15	2.2	8.7	5.2	3.1	2.9	1.6	3.8	.6	—.1	.0	2.6	1.6
16	2.6	7.4	5.8	3.0	2.3	1.6	3.0	.5	—.2	.0	2.6	1.7
17	4.0	7.2	5.0	2.9	1.8	1.6	3.7	.6	—.2	.1	3.9	1.5
18	4.0	6.9	4.8	2.7	1.5	1.5	3.6	.7	—.2	.0	4.5	1.3
19	3.8	6.7	6.4	2.4	1.5	1.5	3.0	.6	—.2	.0	3.6	1.2
20	4.0	5.6	7.3	2.4	1.5	1.8	2.7	.5	—.2	.0	3.0	1.4
21	3.9	5.0	7.8	2.4	1.5	1.5	3.4	.5	—.3	.0	2.0	1.4
22	7.6	4.5	7.5	2.3	1.5	2.0	3.1	.4	—.3	.0	1.8	1.4
23	11.6	4.2	7.2	2.2	1.5	2.0	3.4	.4	1.9	.1	1.2	1.3
24	9.7	3.4	7.0	2.0	1.5	1.8	2.7	.4	1.4	.3	1.1	1.2
25	9.4	3.4	6.3	2.1	1.4	1.5	2.1	.8	.5	.2	1.0	1.1
26	9.3	3.4	5.6	2.2	1.4	1.4	1.9	.6	.2	.1	.9	1.1
27	9.1	3.4	5.0	2.2	1.4	1.4	1.8	.5	.0	.0	.8	1.0
28	8.7	3.4	4.7	2.6	1.4	1.1	1.8	.4	.0	.0	.8	.9
29	7.6	.....	4.4	3.0	3.6	1.0	1.8	.4	—.1	.2	1.0	.9
30	6.2	.....	4.0	4.3	2.6	1.0	1.6	.4	—.1	.1	1.0	.9
31	5.2	.....	3.9	.....	1.8	.....	1.4	.6	.....	.3	.....	.8

Daily gage height, in feet, of Coosa River at Wetumpka, Alabama, for 1897

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.8	2.4	6.0	5.8	4.2	1.7	0.8	1.6	1.0	0.2	0.3	0.2
2	.8	2.4	5.5	6.8	3.6	1.7	.9	1.5	.7	.2	.3	.3
3	.8	4.5	5.5	7.0	3.6	1.6	1.1	1.4	.7	.2	.4	.4
4	.9	6.0	5.2	6.8	3.6	1.6	1.8	1.4	.9	.2	.4	.8
5	.9	7.2	4.7	7.0	3.5	1.6	1.5	1.4	.8	.2	.4	1.9
6	.9	7.9	7.9	9.3	3.4	1.7	1.5	1.4	.8	.2	.4	2.0
7	.9	8.5	13.8	10.0	3.4	1.7	1.7	1.4	.8	.3	.1	2.3
8	.9	9.1	16.7	10.3	3.0	1.6	2.0	1.4	.8	.3	.1	2.5
9	1.1	7.9	18.1	11.5	2.8	1.6	2.1	1.6	.7	.3	.4	2.7
10	1.0	6.8	16.3	12.7	2.8	1.6	2.4	1.8	.7	.4	.5	2.6
11	1.0	6.3	15.7	12.3	2.6	1.5	2.2	1.9	.7	.4	.3	2.6
12	.9	9.3	14.9	10.8	2.5	1.5	2.0	2.0	.5	.4	.2	2.7
13	.9	9.0	17.8	9.0	2.5	1.4	1.8	2.0	.5	.4	.1	3.1
14	.9	9.6	21.4	7.9	2.8	1.4	1.8	2.2	.4	.4	.0	3.5
15	.9	7.3	21.9	6.7	3.0	1.2	1.8	1.8	.3	1.0	.0	3.8
16	.9	6.9	21.9	7.0	6.6	1.2	1.8	1.8	.3	1.0	.2	3.6
17	1.7	6.2	20.7	6.3	6.9	1.0	1.7	2.0	.3	1.2	.2	3.0
18	4.9	5.9	19.1	5.8	6.9	1.4	1.8	2.3	.3	1.0	.2	2.6
19	5.4	5.3	18.7	5.4	6.8	1.2	2.0	2.6	.2	.6	.3	2.5
20	5.4	5.3	17.4	5.0	6.0	1.7	2.4	2.9	.2	.4	.3	2.3
21	8.1	5.0	19.3	4.6	5.3	1.8	4.0	3.0	.2	.4	.2	2.0
22	7.3	4.7	18.4	4.5	4.6	2.0	4.8	3.6	.2	.2	.2	2.0
23	7.3	6.2	20.7	4.0	2.0	1.8	6.0	3.0	.2	.0	.3	2.4
24	7.2	7.3	19.4	4.0	2.0	1.6	7.1	2.4	.1	.0	.3	2.9
25	6.2	8.6	18.7	4.0	1.8	1.4	5.6	1.8	.1	.0	.3	4.1
26	5.6	8.6	17.5	3.8	1.8	1.2	4.6	1.4	.1	.2	.3	4.9
27	4.1	8.2	15.3	3.6	1.8	1.0	3.7	1.4	.0	.2	.3	4.6
28	3.5	7.9	10.7	3.4	1.7	1.0	2.9	1.4	.0	.4	.2	4.1
29	3.0	.....	7.0	3.4	1.7	.8	2.2	1.3	—.1	.4	.2	4.0
30	2.7	.....	6.5	3.7	1.7	.8	1.8	1.3	—.1	.3	.2	3.7
31	2.5	.....	5.5	.....	1.7	.....	1.6	1.1	.....	.3	.....	3.4

MILSTEAD STATION ON TALLAPOOSA RIVER.

This station is located on the bridge of the Tallassee and Montgomery Railroad, about one-quarter of a mile from Milstead, Alabama. The bridge is of iron, two spans of about 155 feet each, with short wood trestles at each end. The banks are high and overflow only at very high stages. The initial point for measurement is the end of iron bridge, left bank downstream side. The rod of wire gage is fastened to outside of guard rail on downstream side of bridge. Its zero is 45 feet from initial point and is 5 feet from center of pulley. The bench mark is top of second crossbeam from left bank pier, downstream end, and is 60.00 feet above datum. Center of pulley is 60.60 feet above datum. The observer is Seth Johnson.

The following discharge measurements were made during 1897 by Max Hall:

May 3, gage height, 6.20 feet; discharge, 7,333 second-feet.
July 15, gage height, 1.95 feet; discharge, 1,692 second-feet.
August 7, gage height, 2.42 feet; discharge, 2,292 second-feet.
September 4, gage height, 1.60 feet; discharge, 1,271 second-feet.
November 23, gage height, 1.20 feet; discharge, 677 second-feet.
December 16, gage height, 3.58 feet; discharge, 4,210 second-feet.

Daily gage height, in feet, of Tallapoosa River at Milstead, Alabama, from August to December, 1897.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.70	0.80	0.90	1.50	17	1.90	1.10	0.80	1.20	2.80
2	.....	1.80	.80	1.00	1.50	18	2.20	1.00	.90	1.20	2.40
3	.....	1.60	.80	1.10	1.50	19	2.80	1.10	.90	1.20	2.10
4	.....	1.60	.70	1.10	1.60	20	9.70	1.10	.90	1.10	2.00
5	.....	1.60	.70	1.10	1.80	21	7.40	1.10	.80	1.20	1.90
6	.....	1.40	.70	1.10	2.00	22	8.50	1.00	.80	1.10	2.00
7	2.45	1.40	.70	1.10	2.10	23	5.30	1.00	.90	1.10	2.40
8	1.90	1.30	.60	1.10	2.00	24	3.40	1.00	.90	1.20	2.40
9	1.70	1.20	.70	1.20	1.90	25	2.90	1.00	.80	1.20	2.40
10	1.50	1.20	.70	1.20	1.90	26	2.80	1.00	.90	1.20	2.80
11	1.50	1.10	.70	1.30	1.90	27	2.30	1.00	.90	1.20	2.60
12	2.70	1.10	.70	1.30	2.00	28	2.00	.90	.90	1.60	2.50
13	2.20	1.10	.70	1.30	1.90	29	1.80	.90	.90	1.50	2.30
14	2.00	1.10	.80	1.30	5.50	30	1.70	.80	.90	1.50	2.20
15	1.80	1.40	.80	1.20	4.70	31	1.70	.....	.90	.....	2.40
16	1.60	1.20	.80	1.20	3.60						

TUSCALOOSA STATION ON BLACK WARRIOR RIVER.

This station, as described in the Eighteenth Annual Report, Part IV, page 103, is located about three-fourths of a mile from the business center of Tuscaloosa, Alabama, and is reached by passing down Bridge street to the river, thence down the east bank 1,800 feet to the gage, which consists of an inclined timber, 2 by 6 inches, supported on posts and graduated by means of notches placed 1 foot vertically apart. The observer is W. S. Wyman, jr., Tuscaloosa, Alabama. The bench marks are fixed, one on a willow 10 feet west of gage, 97.84 feet above Mobile datum, the other on a small hackberry 30 feet south of the upper end of the gage and 139.36 feet above Mobile datum. Zero of gage is 87.30 feet above same datum. The current here is rather sluggish, being almost imperceptible at low stages. Both banks are of earth and subject to overflow. The bed of the stream is composed of sand and gravel. The following discharge measurement was made by B. M. Hall in 1897:

January 12, gage height, 1.70 feet; discharge, 829 second-feet.

Daily gage height, in feet, of Black Warrior River at Tuscaloosa, Alabama, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.34	3.90	11.14	13.90	9.51	1.83	—0.15	1.36	0.60	—1.65	—1.39	—1.28
2	.47	6.00	9.57	15.28	9.95	1.75	— .18	1.08	.96	—1.71	—1.30	—1.12
3	.40	11.50	8.58	22.20	9.22	1.70	— .20	.87	1.02	—1.72	—1.29	— .48
4	.90	12.60	8.72	21.11	7.66	2.01	— .18	.62	.92	—1.75	—1.31	+1.29
5	1.24	11.70	10.14	22.00	6.23	1.98	— .05	.50	.76	—1.79	—1.33	13.10
6	1.11	12.37	16.33	26.95	5.36	2.65	1.63	.40	.62	—1.86	—1.28	14.24
7	1.40	16.24	51.42	25.32	4.67	3.44	3.40	.25	.51	—1.79	—1.27	10.72
8	2.60	18.70	54.77	22.10	4.20	2.87	3.90	.24	.47	—1.85	—1.27	7.39
9	2.66	21.04	51.59	21.30	3.87	2.25	3.71	1.10	.42	—1.88	—1.17	5.12
10	2.30	19.80	44.69	29.27	3.50	1.85	3.05	2.10	.36	—1.90	—1.13	3.72
11	2.03	17.90	40.54	29.57	3.20	1.60	2.53	3.26	.29	—1.90	—1.10	3.05
12	1.76	23.12	42.53	25.48	3.64	1.39	2.42	3.22	.23	—1.88	—1.14	2.70
13	1.52	25.90	48.70	21.60	11.40	1.24	2.16	2.73	.14	—1.89	—1.17	2.56
14	1.33	23.84	50.96	18.10	20.36	1.11	1.86	2.27	.11	—1.92	—1.25	3.05
15	1.23	20.30	48.57	16.32	20.46	.95	1.46	1.63	.10	—1.92	—1.25	3.54
16	8.23	16.96	45.20	18.43	16.59	.85	1.16	1.28	.06	—1.92	—1.27	4.12
17	9.70	14.04	47.21	18.33	12.68	.75	.97	1.00	.01	—1.90	—1.33	4.10
18	13.10	11.72	46.72	15.92	9.77	.63	1.50	.73	— .05	—1.90	—1.35	3.78
19	19.35	9.97	42.90	13.66	7.73	1.30	3.50	.52	— .36	—1.90	—1.36	3.50
20	18.70	8.77	42.57	11.86	6.35	1.45	12.50	1.53	— .75	—1.88	—1.36	3.82
21	17.43	8.08	44.54	10.45	5.37	1.11	14.50	1.78	— .95	—1.88	—1.36	6.70
22	18.64	8.32	41.50	9.24	4.66	.80	11.30	1.58	—1.07	—1.77	—1.37	19.58
23	16.52	11.00	37.70	8.15	4.13	.55	8.42	1.33	—1.17	—1.64	—1.42	31.00
24	13.30	20.20	35.66	7.37	3.70	.33	6.64	1.08	—1.26	—1.58	—1.44	29.96
25	10.60	21.24	32.40	6.80	3.45	.23	4.77	1.27	—1.24	—1.63	—1.40	24.08
26	8.60	18.97	28.86	6.37	3.13	.16	3.46	.97	—1.36	—1.63	—1.36	18.97
27	7.20	16.18	25.60	5.90	2.90	.12	2.72	.80	—1.41	—1.61	—1.36	15.67
28	6.00	13.31	23.15	5.49	2.60	.03	2.92	.61	—1.44	—1.64	—1.28	13.10
29	5.10	.....	20.33	5.10	2.28	.00	2.15	.54	—1.50	—1.61	—1.22	11.00
30	4.42	.....	17.52	5.90	2.09	— .08	1.80	.46	—1.55	—1.63	—1.24	9.38
31	3.80	.....	14.98	.....	2.00	.....	1.62	.31	.....	—1.63	.....	8.00

ALDERSON STATION ON GREENBRIER RIVER.

This station is described in the Eighteenth Annual Report, Part IV, page 111. It is located one-half mile above the mouth of Muddy Creek, on the county bridge at Alderson, West Virginia. The wire gage is in the third panel of the second span, lower side. The distance from the end of the weight to the marker is 28.37 feet. The distance from the zero of the gage to the top of the lower end of the third floor beam, second span, from the left bank, is 22.47 feet. Bench marks: Upper end of coping of the first pier from left bank 21.75 feet above the zero of the gage; upper end of the bridge seat of the left bank abutment 21.61 feet above the zero of the gage; stone foundation of the water tank of the Chesapeake and Ohio Railway 23.48 feet above the zero of the gage. The observer is W. J. Hancock, clerk in the store of George Graves. The following measurements of discharge were made by Prof. D. C. Humphreys and F. H. Anschutz in 1897:

March 30, gage height, 2.75 feet; discharge, 1,639 second-feet.
May 3, gage height, 4.88 feet; discharge, 6,181 second-feet.
May 4, gage height, 4.29 feet; discharge, 4,963 second-feet.
May 4, gage height, 4.38 feet; discharge, 5,450 second feet.
May 6, gage height, 3.56 feet; discharge, 3,158 second-feet.
May 13, gage height, 12.30 feet; discharge, 32,563 second-feet.
May 14, gage height, 12.33 feet; discharge, 33,034 second-feet.
May 14, gage height, 9.53 feet; discharge, 20,722 second-feet.
May 31, gage height, 2.26 feet; discharge, 681 second feet.
October 12, gage height, 1.42 feet; discharge, 71 second-feet.

Daily gage height, in feet, of Greenbrier River at Alderson, West Virginia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.00	2.22	3.05	2.77	2.18	2.55	2.03	2.35	1.62	1.43	1.40	2.00
2	1.95	2.21	2.90	2.75	3.44	2.65	3.40	2.25	1.58	1.38	1.52	1.90
3	1.98	2.20	2.80	2.67	4.80	2.45	4.30	2.45	1.58	1.40	1.48	1.85
4	2.00	2.05	2.75	2.63	4.44	2.35	3.40	2.45	1.55	1.40	1.58	1.85
5	2.10	2.02	3.13	2.78	3.90	2.50	2.87	2.34	1.50	1.45	1.55	2.30
6	2.85	4.04	3.15	4.83	3.60	2.47	3.40	2.30	1.50	1.44	1.60	3.26
7	2.80	6.62	3.42	4.18	3.52	2.40	3.35	2.18	1.53	1.41	1.60	3.17
8	2.45	5.20	3.80	3.65	3.25	2.28	3.25	2.15	1.50	1.40	1.66	2.68
9	2.35	4.20	3.50	3.50	3.03	2.26	2.93	2.05	1.48	1.40	1.62	2.43
10	2.35	3.55	3.60	4.78	2.92	2.30	2.75	2.00	1.50	1.38	1.60	2.25
11	2.35	3.43	4.85	4.50	2.83	2.23	2.45	2.00	1.49	1.36	1.60	2.05
12	2.20	4.08	4.52	4.00	3.16	2.17	2.70	1.97	1.48	1.40	1.60	2.05
13	2.05	5.40	4.65	3.50	8.26	2.20	2.60	1.91	1.44	1.41	1.90	1.98
14	2.00	5.07	4.40	3.20	12.20	2.23	2.38	1.85	1.44	1.42	1.63	1.95
15	1.95	5.00	6.10	3.05	6.01	2.20	2.28	1.83	1.43	1.43	1.75	1.97
16	2.20	5.10	5.12	3.00	4.75	2.98	2.17	1.83	1.42	1.43	1.72	2.37
17	2.20	5.10	4.10	2.95	4.05	2.65	2.08	1.80	1.40	1.43	1.74	3.07
18	2.20	4.45	3.80	2.95	3.55	2.55	2.00	1.78	1.40	1.37	1.68	2.77
19	2.60	4.48	6.00	2.82	3.25	2.45	2.10	1.75	1.38	1.52	1.65	2.60
20	2.65	4.38	6.75	2.75	3.05	2.90	2.15	1.72	1.38	1.50	1.67	2.55
21	2.55	4.35	6.15	2.68	2.90	2.95	2.34	1.70	1.40	1.52	1.65	2.68
22	2.55	10.08	4.15	2.58	2.80	2.80	4.85	1.67	1.40	1.53	1.67	4.30
23	2.60	16.93	3.95	2.50	2.68	2.65	4.65	1.67	1.37	1.50	1.67	3.83
24	2.60	9.23	3.55	2.45	2.58	2.50	4.00	1.80	1.37	1.50	1.60	3.20
25	2.45	5.80	3.45	2.35	2.50	2.45	4.05	1.73	1.38	1.50	1.60	2.85
26	2.50	4.55	3.25	2.35	2.50	2.48	3.28	1.77	1.40	1.54	1.57	2.50
27	2.42	3.80	3.07	2.35	2.42	2.20	3.46	1.68	1.35	1.52	1.55	2.35
28	2.35	3.35	2.95	2.28	2.33	2.13	3.40	1.68	1.40	1.52	1.55	2.43
29	2.25	.....	2.88	2.25	2.28	2.05	2.65	1.70	1.40	1.52	1.78	2.25
30	2.20	.....	2.82	2.20	2.23	2.00	2.57	1.66	1.40	1.48	2.07	2.15
31	2.20	.....	2.80	.....	2.25	.....	2.48	1.64	.....	1.45	.....	2.15

FAYETTE STATION ON NEW RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 113, is located just below the mouth of Wolf Creek on a highway bridge of one span, at Fayette, West Virginia. The wire gage is located on the guard rail, on the upper side of the bridge about the middle of the span, and the graduation is to feet and tenths. Bench marks: The top of the bottom plate of the lower plate girder, at the end of the first panel from the left bank, lower side, is 55.13 feet above the zero of the gage; top of lower end of coping on the main pier, right bank, lower side, 52.13 feet above the zero of the gage; bridge seat, on the right bank, lower side, 54.58 feet above the zero of the gage; west corner of abutment stone, by Chesapeake and Ohio Railway station, 58.62 feet above the zero of the gage. The observer is M. W. Brellahan, agent Chesapeake and Ohio Railway. The following discharge measurements were made by Prof. D. C. Humphreys and F. H. Anschutz in 1897:

March 31, gage height, 5.50 feet; discharge, 9,587 second-feet.
May 5, gage height, 8.50 feet; discharge, 15,931 second-feet.
May 15, gage height, 13.98 feet; discharge, 35,195 second-feet.
May 31, gage height, 3.70 feet; discharge, 5,145 second-feet.
October 12, gage height, —0.18 foot; discharge, 1,136 second-feet.
November 5, gage height, 1.72 feet; discharge, 2,616 second-feet.

Daily gage height, in feet, of New River at Fayette, West Virginia, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.80	1.90	7.20	6.00	4.30	3.25	2.25	4.07	1.20	0.10	1.40	0.40
2	2.30	2.05	6.65	5.50	4.30	3.60	3.15	3.25	1.10	.05	1.55	.45
3	3.00	2.20	6.35	5.05	7.80	3.65	3.55	2.85	1.05	.05	1.80	1.15
4	3.30	3.05	6.05	5.90	9.52	3.50	4.52	2.40	.95	.01	1.90	1.25
5	3.60	4.30	6.15	6.95	9.25	3.33	4.50	2.50	.90	.00	1.75	1.25
6	3.20	6.50	6.50	7.10	7.48	3.30	4.10	2.90	.65	.00	2.00	1.05
7	3.50	16.72	7.25	9.80	6.50	4.70	3.73	2.80	.50	.05	2.40	1.10
8	4.00	14.10	7.40	11.10	6.20	5.00	4.75	2.75	.45	.10	1.50	3.75
9	3.50	8.60	7.70	7.80	5.25	5.95	3.80	4.60	.40	.10	1.30	3.00
10	3.35	6.03	12.05	8.10	5.15	6.55	3.50	4.05	.35	.05	1.25	2.95
11	3.00	6.40	16.00	9.75	4.75	6.22	3.45	3.00	.35	.00	1.20	1.85
12	2.90	9.20	11.70	8.50	5.95	5.25	3.85	2.50	.20	.00	1.00	1.20
13	2.35	13.70	14.00	8.00	6.12	5.00	3.50	2.25	.00	.00	.80	1.15
14	2.05	14.70	15.20	7.15	20.58	4.60	3.05	2.10	.95	5.56	.70	1.30
15	2.30	14.00	17.40	6.45	16.19	3.55	2.40	2.00	.80	2.95	.70	1.80
16	2.10	13.25	16.80	6.10	11.00	3.40	1.90	1.60	.75	1.85	.70	1.70
17	2.45	10.10	15.70	6.30	8.20	3.80	2.00	1.30	.90	1.05	.60	1.75
18	2.75	9.90	13.00	6.05	7.50	3.50	2.25	1.25	.90	.90	.55	3.50
19	3.00	9.00	14.10	5.80	6.55	3.10	2.25	1.35	.90	.70	.45	3.40
20	3.45	9.25	12.30	5.45	5.70	4.40	2.45	1.40	.50	.60	.40	3.20
21	4.00	20.10	11.40	5.15	5.35	4.85	2.90	1.80	.50	.45	.40	3.00
22	4.50	26.12	10.30	4.85	5.00	5.25	5.50	1.90	.50	.50	.35	3.40
23	4.70	27.55	9.60	4.50	4.65	5.38	8.10	1.85	.00	4.05	.20	5.25
24	4.00	23.18	9.20	4.20	4.10	3.95	11.48	1.75	.50	2.35	.10	3.85
25	3.80	18.30	8.70	4.10	4.00	3.40	10.00	1.75	.50	1.50	.15	3.10
26	2.90	11.55	8.25	4.00	3.85	3.25	9.50	1.85	.65	1.10	.25	3.10
27	2.30	8.15	7.00	3.85	3.30	3.08	8.20	1.80	.75	1.05	.00	2.40
28	1.95	7.80	6.70	3.70	3.30	2.57	7.85	1.90	.80	.95	.05	2.40
29	1.60	.....	6.65	3.60	3.90	2.38	6.70	1.90	.60	.90	.20	1.90
30	1.35	.....	6.40	3.50	3.78	2.35	5.30	1.60	.30	.80	.20	2.10
31	1.60	.....	6.25	.....	3.70	.....	4.25	1.35	.....	1.10	.....	2.00

ASHEVILLE STATION ON FRENCH BROAD RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 116, is located at the Bingham school iron highway bridge, 3 miles west of Asheville, North Carolina, and is reached by electric-car line. It is also 3 miles below the mouth of Swannanoa River. The gage is a wire one. The zero of the rod is opposite the east edge of the fifth upright, first span from east, upper side. The outside edge of the pulley is 3 feet from the end of the rod, and the length of the wire cable from the end of the weight to the index marker is 26.03 feet. When the gage height is 3.22 feet the water surface is 17.18 feet below top of the lower end of the second floor beam, first span from the east.

The initial point for soundings is on the right bank, at the end of the first span of the bridge. Both banks may overflow in very high water. The current is swift and the channel is rough and rocky, and reasonably permanent. The observer is J. M. Taylor, a carpenter of Asheville, North Carolina. The following discharge measurements were made by E. W. Myers and others during 1897:

August 18, gage height, 2.86 feet; discharge, 882 second-feet.
October 14, gage height, 2.84 feet; discharge, 808 second-feet.
October 27, gage height, 2.50 feet; discharge, 734 second-feet.

Daily gage height, in feet, of French Broad River at Asheville, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.80	3.60	3.90	4.25	7.10	3.30	3.30	2.75	2.65	2.30	2.90	2.85
2	2.75	3.80	3.80	4.20	7.00	3.25	3.15	2.80	2.63	2.30	3.85	2.85
3	2.70	4.60	3.80	4.15	3.90	3.90	3.05	2.85	2.60	2.30	3.83	2.90
4	2.90	4.90	3.80	5.30	5.70	3.95	3.10	2.95	2.60	2.27	3.77	3.00
5	3.25	4.90	3.70	7.60	4.50	3.85	3.15	2.95	2.60	2.27	2.95	3.00
6	3.25	7.90	7.00	7.30	4.30	3.40	3.25	3.10	2.55	2.25	2.85	2.90
7	2.95	7.40	7.25	6.90	4.00	3.30	3.35	4.00	2.55	2.25	2.65	2.83
8	2.93	6.40	5.50	6.50	3.90	4.50	3.37	4.00	2.53	2.23	2.55	2.77
9	2.93	4.85	5.00	5.40	3.85	3.80	3.37	3.05	2.45	2.23	2.53	2.65
10	2.87	4.55	5.10	5.35	3.80	3.65	3.25	3.03	2.40	2.23	2.50	2.63
11	2.85	4.60	5.20	4.60	3.60	3.40	3.60	3.00	2.37	3.35	2.47	2.60
12	2.85	4.70	6.20	4.55	3.45	3.30	3.40	2.80	2.37	3.30	2.46	2.60
13	2.87	4.60	6.43	4.40	4.00	3.20	3.20	2.73	2.35	3.20	2.45	2.55
14	2.90	4.55	7.00	4.60	4.15	3.15	3.25	2.70	2.35	2.83	2.45	2.45
15	2.85	4.35	5.90	4.60	4.00	3.05	3.30	2.70	2.40	2.75	2.45	2.45
16	2.83	4.15	6.40	4.50	3.70	3.30	3.30	2.80	2.40	2.65	2.45	3.15
17	2.95	3.95	5.90	4.35	3.65	3.40	3.40	2.85	2.35	2.63	2.43	3.15
18	3.35	3.90	5.30	4.15	3.65	3.55	3.35	2.87	2.33	2.45	2.43	3.10
19	3.15	3.85	5.45	4.10	3.55	3.60	3.35	2.85	2.37	3.25	2.40	2.95
20	3.50	3.75	5.85	4.05	3.53	3.35	3.25	2.92	2.35	3.23	2.37	3.00
21	4.45	4.15	5.50	4.00	3.50	3.35	3.40	2.90	2.33	2.85	2.27	3.15
22	4.40	3.90	4.90	3.90	3.50	3.25	3.55	2.90	2.40	2.75	2.35	3.20
23	3.65	6.85	4.75	3.85	3.50	3.40	3.40	2.85	2.50	2.67	2.33	3.25
24	3.55	6.05	4.65	3.85	3.50	3.55	3.35	2.83	2.45	2.65	2.35	3.20
25	3.45	4.86	4.55	3.75	3.45	3.40	3.30	2.70	2.43	2.63	2.40	3.05
26	3.35	4.35	4.45	3.70	3.35	3.35	3.15	2.70	2.43	2.50	2.60	3.25
27	3.35	4.20	4.45	3.70	3.37	3.30	3.20	2.70	2.40	2.50	2.90	3.40
28	3.45	4.15	4.35	3.67	3.27	3.50	3.10	2.65	2.37	2.47	2.85	3.65
29	3.43	.....	4.10	3.65	3.25	3.65	3.05	2.50	2.35	2.45	2.83	3.57
30	3.33	.....	4.00	5.40	3.35	3.45	3.00	2.55	2.33	2.45	2.90	3.50
31	3.45	.....	4.10	.....	3.35	.....	2.75	2.57	.....	2.45	.....	3.40

BRYSON STATION ON TUCKASEEGEE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 116, was located on the Southern Railway bridge about 3 miles above Bryson, North Carolina, and just below Governor Island post-office, and was abandoned March 25 because the section was poor. A new station was established November, 1897, in the town of Bryson, at the highway bridge. The bottom is muddy, the water is deep, and the current is very sluggish. The gage is bolted to the north pier and lower side, and can be read from the bridge. The initial point for soundings is the south end, upstream hand-rail. The channel is obstructed by the remains of two old piers. The observer is H. H. Welch. The following discharge measurement was made in 1897 by A. P. Davis:

October 28, gage height, 1.00 foot; discharge, 168 second-feet.

Daily gage height, in feet, of Tuckaseegee River at Bryson, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Nov.	Dec.	Day.	Jan.	Feb.	Mar.	Nov.	Dec.
1	2.25	3.10	3.75	.....	1.25	17	2.90	3.60	5.70	1.00	1.30
2	2.20	3.80	3.60	.....	1.10	18	3.30	3.50	5.80	1.00	1.30
3	2.30	3.10	4.40	.....	1.35	19	2.90	3.50	6.90	1.00	1.60
4	2.50	3.00	3.65	.....	1.60	20	3.30	3.70	5.70	1.00	1.70
5	2.80	3.30	3.60	.....	2.30	21	3.30	4.30	5.60	1.00	3.40
6	2.40	5.52	7.50	.....	1.60	22	3.30	4.55	5.40	1.00	2.60
7	2.40	4.70	5.60	1.05	1.30	23	3.25	4.90	5.10	1.00	2.05
8	2.40	4.10	4.90	1.00	1.25	24	3.00	8.85	5.00	1.00	1.70
9	2.40	4.00	5.00	1.15	1.20	25	2.90	5.30	4.80	1.00	1.60
10	2.30	3.80	7.10	1.10	1.15	26	2.85	4.70	.....	1.00	1.70
11	2.30	4.00	5.30	1.00	1.15	27	2.80	4.30	.....	1.40	1.65
12	2.40	5.40	9.15	1.00	1.15	28	2.20	3.90	.....	1.20	1.50
13	2.30	5.00	6.80	1.00	1.30	29	2.20	.....	.....	1.30	1.45
14	3.00	4.15	7.70	1.00	2.00	30	2.60	.....	.....	1.30	1.40
15	2.80	3.90	6.20	1.00	1.70	31	2.90	.....	.....	.....	1.50
16	2.60	3.80	6.90	1.00	1.40						

JUDSON STATION ON LITTLE TENNESSEE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 117, is located on the Southern Railway bridge about one-fourth of a mile from Judson, North Carolina, and below the mouth of Sawyer Branch. The zero of the gage rod is 25 feet west of the east end of the second span from the east. The outer rim of the pulley wheel is 2 feet from the zero of the gage rod, and the distance from the end of the weight to the marker on the wire rope is 26.25 feet. The gage reads zero when the weight touches the bottom of the stream. The bottom is rocky and very rough on the west side of the stream, and sandy on the east side, and the current is very swift. The river is straight for several hundred yards above and below the station. The section is not a very good one, as there are two bad pier obstructions. The observer is R. C. Sawyer, Judson, North Carolina. The following discharge measurements were made by E. W. Myers and A. P. Davis in 1897:

August 21, gage height, 3.21 feet; discharge, 771 second-feet.
October 13, gage height, 2.75 feet; discharge, 701 second-feet.
October 28, gage height, 2.44 feet; discharge, 448 second-feet.

Daily gage height, in feet, of Little Tennessee River at Judson, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.40	5.50	4.20	6.23	4.20	3.82	3.30	3.48	2.83	2.52	2.38	2.58
2	3.56	6.40	3.56	7.50	3.56	3.78	3.50	3.46	2.85	2.53	3.30	2.56
3	3.53	5.54	3.56	7.91	3.54	2.91	3.42	3.39	2.89	2.60	2.86	2.55
4	3.54	4.80	3.53	7.90	3.52	4.20	3.50	3.43	2.86	2.54	2.70	3.00
5	3.51	4.59	3.56	6.55	3.53	4.80	3.60	3.45	2.84	2.55	2.58	4.58
6	3.52	5.30	4.50	6.53	3.58	3.90	3.70	3.40	2.84	2.57	2.79	4.39
7	3.65	4.56	4.35	5.80	3.57	3.59	3.63	3.46	2.85	2.50	2.80	4.00
8	3.65	4.59	4.59	5.70	3.57	3.58	3.67	3.48	2.73	2.56	2.72	3.80
9	3.64	4.50	6.40	5.30	3.22	3.55	3.75	3.47	2.71	2.53	2.73	3.00
10	3.63	4.47	7.29	4.23	3.23	3.56	3.72	3.44	2.73	4.54	2.78	2.90
11	3.69	5.20	7.38	4.50	3.27	3.59	3.70	3.38	2.77	4.58	2.70	2.89
12	3.65	5.28	9.20	4.60	3.27	3.57	3.48	3.35	2.89	2.56	2.76	2.86
13	3.66	5.26	7.32	5.70	4.76	3.58	3.49	3.36	2.89	2.49	2.79	2.80
14	3.65	5.30	7.23	5.23	5.21	3.53	3.42	3.32	2.83	2.50	2.61	3.51
15	3.64	4.59	7.15	4.59	5.13	3.59	3.45	3.35	2.88	2.53	2.63	3.00
16	3.62	4.56	6.35	5.40	4.12	3.61	3.51	4.00	2.86	2.53	2.68	3.00
17	3.65	3.70	5.53	4.54	4.90	3.62	4.33	3.86	2.90	2.54	2.73	2.89
18	3.64	3.80	6.95	3.53	4.70	3.60	4.56	3.86	2.90	2.60	2.70	2.90
19	3.69	3.53	7.65	3.52	4.30	3.60	4.91	3.78	2.80	2.22	2.69	2.96
20	4.80	3.52	8.90	3.15	3.57	3.48	5.20	3.52	2.38	3.48	2.67	3.40
21	4.80	4.30	8.00	3.22	3.56	3.50	4.36	3.32	2.40	3.37	2.68	3.58
22	4.82	5.60	8.50	3.21	3.56	3.42	4.20	3.22	2.37	2.86	2.60	4.56
23	4.62	8.60	7.53	3.18	3.41	3.44	4.21	3.23	2.33	2.70	2.65	4.59
24	4.60	6.75	7.85	3.18	3.90	3.47	3.78	3.35	2.39	2.72	2.67	3.48
25	3.90	4.75	6.25	3.32	3.70	3.41	3.72	3.29	2.50	2.60	2.70	3.36
26	3.84	4.63	5.55	3.39	3.90	3.48	3.70	3.90	2.60	2.63	2.82	3.38
27	3.84	4.53	5.53	3.30	3.80	3.46	3.73	3.00	2.52	2.35	3.10	3.30
28	3.83	4.29	5.60	3.41	3.51	3.45	3.71	3.33	2.50	2.39	2.89	3.00
29	3.68	.....	5.56	3.90	3.60	3.43	3.75	2.78	2.53	2.39	2.80	2.97
30	3.69	.....	5.70	3.99	3.90	3.40	3.71	2.79	2.57	2.38	2.86	2.78
31	3.65	.....	6.21	.....	3.80	.....	3.69	2.77	.....	2.34	.....	2.90

MURPHY STATION ON HIWASSEE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 117, is located on the highway bridge crossing the river at Murphy, North Carolina, one-half mile above Valley River. The zero of the gage rod is 8 feet north of the center of the second full-length compression member from the north end and on the downstream side of bridge. The outer rim of the pulley wheel is 2 feet from the zero of the gage rod, and the distance from the end of the weight to the marker on the wire is 29.10 feet. The reading of the gage is zero when the weight touches the bottom of the river. The section here is a fairly good one, though somewhat obstructed by the remains of two old piers directly under the present bridge. The course of the stream is straight for several hundred yards above and below the bridge and the current fairly rapid. The bottom is hard and rocky and is not subject to any decided change by high water. The banks are high and not subject to overflow except in very high water. The observer here is M. L. Brittain. The following measurements were made by E. W. Myers and A. P. Davis in 1897:

August 20, gage height, 5.33 feet; discharge, 528 second-feet.
October 14, gage height, 4.76 feet; discharge, 267 second-feet.
October 29, gage height, 4.71 feet; discharge, 253 second-feet.

Daily gage height, in feet, of Hiwassee River at Murphy, North Carolina, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.90	4.80	4.60	5.40	4.80	4.16	3.90	4.20	.....	.....	5.00	5.02
2	3.90	5.50	4.50	5.50	4.70	4.15	3.90	4.32	.....	.....	5.40	5.00
3	3.90	4.90	4.55	5.38	4.65	4.12	3.90	4.20	.....	.....	5.10	5.10
4	3.90	4.62	4.70	6.26	4.60	4.10	3.90	4.10	.....	.....	5.02	5.45
5	4.12	4.60	4.60	8.20	4.55	4.30	4.15	4.35	.....	.....	5.00	6.10
6	4.02	5.15	9.20	6.12	4.52	4.12	4.00	4.20	.....	.....	5.00	5.50
7	4.00	5.40	6.50	5.75	4.50	4.10	4.02	4.20	.....	.....	4.95	5.30
8	4.00	5.12	5.65	5.50	4.50	4.10	4.10	.....	.....	.....	5.00	5.20
9	3.92	5.10	5.40	6.10	4.50	4.22	4.10	.....	.....	.....	4.98	5.12
10	3.92	4.85	5.62	5.35	4.45	4.10	4.25	.....	.....	.....	5.00	5.10
11	4.00	4.85	5.50	5.30	4.52	4.02	4.15	.....	.....	.....	5.00	5.10
12	3.90	4.82	9.90	5.15	4.40	4.05	4.00	.....	.....	.....	4.95	5.00
13	3.92	4.82	6.85	5.05	5.00	4.05	3.98	.....	.....	.....	4.95	5.02
14	4.40	4.12	6.70	5.05	4.80	4.00	3.90	.....	.....	.....	5.00	6.20
15	4.60	4.70	6.12	5.50	4.60	4.00	3.85	.....	.....	.....	5.00	5.55
16	4.15	4.60	7.65	5.05	4.50	4.10	3.90	.....	.....	.....	5.00	5.30
17	4.55	.....	6.30	5.00	4.50	4.03	4.50	.....	.....	.....	4.95	5.28
18	4.40	.....	6.00	4.90	4.42	4.10	4.05	.....	.....	.....	4.95	5.20
19	4.40	.....	7.05	4.80	4.40	4.20	5.72	.....	.....	.....	4.95	5.40
20	5.10	.....	6.80	4.80	4.32	4.15	5.00	.....	.....	5.00	4.95	6.00
21	4.70	4.80	6.10	4.70	4.36	4.05	4.50	.....	.....	4.75	4.95	7.35
22	4.52	4.50	5.80	4.70	4.35	4.00	4.85	.....	.....	4.75	4.95	6.85
23	4.40	7.92	5.55	4.70	4.30	4.00	4.34	.....	.....	4.70	4.90	6.15
24	4.40	5.50	5.40	4.70	4.26	4.00	4.20	.....	.....	4.70	4.90	5.80
25	4.40	5.10	5.30	4.65	4.25	4.00	10.85	.....	.....	4.70	5.00	5.50
26	4.20	4.97	5.15	4.70	4.22	4.00	6.20	.....	.....	4.65	4.98	5.85
27	4.30	4.70	5.10	4.63	4.20	3.90	5.20	.....	.....	4.66	5.00	5.60
28	4.10	4.64	5.00	4.60	4.20	3.90	4.72	.....	.....	4.70	5.05	5.50
29	4.15	.....	4.90	4.60	4.20	4.30	4.52	.....	.....	4.72	5.00	5.40
30	4.15	.....	5.00	4.68	4.20	4.00	4.40	.....	.....	4.90	5.10	5.40
31	4.15	.....	4.90	.....	4.20	.....	4.25	.....	.....	4.87	.....	5.30

CHATTANOOGA STATION ON TENNESSEE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 119, is located on the Tennessee River at the city of Chattanooga, Tennessee. The gage is on an incline of railroad iron for about 20 feet in its lower portion. Above this it is a vertical rod bolted to the vertical rock bluff forming the river bank. The zero of the gage is 630.64 feet above sea level. It is located at the foot of Lookout street, just below Chattanooga Island. Measurements are made from the Hamilton County steel highway bridge at the foot of Walnut street, a short distance below the gage. The observer is L. M. Prindell. The following discharge measurements were made by Max Hall and others during 1897:

May 8, gage height, 7.07 feet; discharge, 44,187 second-feet.
May 28, gage height, 4.52 feet; discharge, 25,892 second-feet.
June 29, gage height, 5.76 feet; discharge, 32,943 second-feet.
July 13, gage height, 4.59 feet; discharge, 26,884 second-feet.
September 7, gage height, 1.67 feet; discharge, 10,313 second-feet.
October 6, gage height, 0.48 foot; discharge, 5,969 second-feet.
November 16, gage height, 0.83 foot; discharge, 5,552 second-feet.
December 23, gage height, 10.30 feet; discharge, 67,000 second-feet.

Daily gage height, in feet, of Tennessee River at Chattanooga, Tennessee, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.4	3.0	12.5	8.7	5.9	4.3	5.0	4.4	2.1	0.8	0.8	1.0
2	2.5	7.0	9.6	12.2	6.3	4.2	4.6	3.9	2.2	.8	.9	1.2
3	2.8	10.1	8.6	15.0	7.4	4.1	3.8	3.8	1.9	.7	1.0	1.3
4	2.6	10.5	9.0	16.0	9.6	4.1	3.4	3.6	1.8	.6	1.2	2.0
5	2.6	9.4	9.5	26.0	9.6	4.1	3.4	3.3	1.8	.5	1.2	3.3
6	2.7	8.3	12.1	30.4	8.5	4.1	4.0	3.5	1.7	.5	1.3	3.8
7	2.9	8.8	19.2	29.7	7.7	4.4	3.8	4.4	1.7	.5	1.4	3.9
8	3.0	10.7	25.1	25.4	7.2	4.4	3.8	4.2	1.6	.4	1.2	3.5
9	2.8	14.1	24.2	20.0	6.6	4.0	4.4	4.2	1.6	.4	1.2	2.9
10	2.8	15.5	21.3	16.0	6.2	5.2	4.0	5.6	1.4	.4	1.2	2.6
11	2.7	13.2	22.3	14.0	6.0	5.0	4.1	5.2	1.3	.5	1.1	2.4
12	2.6	10.8	28.4	26.0	6.2	5.7	4.5	4.6	1.2	.6	1.0	2.1
13	2.4	9.9	34.9	11.4	7.8	5.0	4.6	4.1	1.2	.9	1.0	1.8
14	2.6	10.0	37.9	10.3	18.4	4.3	4.2	3.5	1.1	1.4	.9	1.8
15	4.1	10.5	37.9	9.7	22.4	3.9	3.8	3.1	1.0	1.1	.8	2.5
16	6.5	10.7	37.0	9.8	20.3	3.6	3.6	2.8	1.0	1.2	.8	2.7
17	6.6	9.8	36.0	10.2	16.5	3.7	4.5	2.8	.9	1.2	.8	2.5
18	6.3	8.6	33.8	9.9	11.9	3.6	6.3	3.0	.9	1.2	.8	2.5
19	6.4	7.6	29.6	9.3	9.1	3.3	6.1	3.4	.8	1.1	.8	2.6
20	6.8	7.0	29.6	8.8	7.7	3.3	5.6	3.0	.8	1.4	.7	3.4
21	7.0	7.0	32.4	8.1	6.9	4.1	6.7	3.0	.9	2.0	.7	4.5
22	7.2	8.3	33.3	7.5	6.4	5.0	6.1	3.4	.9	1.9	.7	7.1
23	7.3	13.2	30.9	7.0	5.9	4.8	5.8	3.1	.8	1.6	.7	10.2
24	7.0	25.2	25.0	6.7	5.6	5.3	6.0	3.8	.9	1.4	.7	9.3
25	6.6	31.6	18.1	6.4	5.3	5.5	8.4	3.4	.8	1.6	.7	7.7
26	5.9	34.8	14.2	6.2	5.1	6.2	9.7	2.9	.8	1.4	.7	6.4
27	5.3	33.8	12.2	6.0	4.8	5.4	13.3	2.8	.7	1.2	.7	5.6
28	4.8	23.6	10.8	6.1	4.6	5.5	8.7	2.8	.7	1.0	.7	5.0
29	4.4	.....	9.8	6.2	4.4	6.2	6.7	2.5	.7	.9	.7	4.5
30	3.7	.....	9.1	5.8	4.2	5.2	5.6	2.2	.8	.8	.9	4.0
31	3.0	.....	8.6	.....	4.2	.....	5.0	2.1	.....	.8	.....	3.8

TOWNSEND STATION ON MISSOURI RIVER.

This station, mentioned in the Eighteenth Annual Report, Part IV, page 123, and described more fully in Bulletin No. 131, page 22, is located on a wagon bridge about a mile north of the railroad station at Townsend, Montana, and immediately below the railroad bridge. The heights given are the means of two daily readings expressed in feet above the St. Louis directrix, which is 412.73 feet above mean gulf level. This gage is maintained by Capt. J. C. Sanford, Corps of Engineers, U. S. A., Sioux City, Iowa, and copies of the record are sent weekly to the office of the Missouri River Commission. The secretary of that commission, Capt. Hiram M. Chittenden, has kindly furnished this office with the record for the year 1897. In the following table, taken from this record, the figures 3,300 have been omitted. It is, therefore, necessary to add 3,300 to obtain elevation above the St. Louis directrix. The following discharge measurements have been made by Roe Emery during 1897:

May 10, gage height, 92.10 feet; discharge, 14,247 second-feet.
May 19, gage height, 92.50 feet; discharge, 19,466 second-feet.
June 12, gage height, 91.00 feet; discharge, 12,352 second-feet.
June 23, gage height, 90.28 feet; discharge, 8,189 second-feet.
July 12, gage height, 89.50 feet; discharge, 5,917 second-feet.
July 27, gage height, 88.85 feet; discharge, 3,797 second-feet.
August 12, gage height, 88.50 feet; discharge, 2,901 second-feet.
September 17, gage height, 88.40 feet; discharge, 2,695 second-feet.

Daily gage height, in feet, of Missouri River at Townsend, Montana, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	88.8	92.1	91.5	89.1	90.6	92.5	90.1	88.7	88.2	88.6	88.8	a93.3
2	88.8	92.2	91.4	89.0	90.7	92.7	90.2	88.7	88.2	88.6	88.8	93.3
3	88.8	92.4	91.3	89.0	90.9	92.6	90.2	88.7	88.3	88.6	88.8	93.3
4	88.8	92.5	91.2	89.0	91.2	92.3	90.2	88.7	88.4	88.6	88.7	93.3
5	88.8	92.6	91.1	89.1	91.4	91.9	90.2	88.6	88.4	88.6	88.7	93.3
6	88.6	92.7	91.1	89.1	91.6	91.6	90.2	88.5	88.4	88.6	88.7	93.3
7	88.6	92.8	91.1	89.1	91.7	91.4	90.1	88.5	88.4	88.6	88.7	93.3
8	88.5	92.8	91.1	89.1	91.9	91.3	90.0	88.5	88.4	88.6	88.7	93.1
9	88.5	92.6	91.1	89.2	92.1	91.3	89.8	88.4	88.4	88.6	88.7	92.9
10	88.5	92.6	91.0	89.1	91.9	91.2	89.7	88.4	88.4	88.6	88.7	92.6
11	88.5	92.5	90.0	89.1	91.4	91.1	89.6	88.4	88.4	88.6	88.7	92.3
12	88.5	92.4	90.8	89.2	91.1	91.0	89.4	88.4	88.4	88.6	88.7	92.1
13	88.5	92.4	90.7	89.4	91.1	90.9	89.4	88.4	88.4	88.6	88.7	92.1
14	91.4	92.4	90.7	89.5	91.1	90.8	89.3	88.4	88.4	88.6	88.7	92.2
15	91.4	92.4	90.7	89.8	91.5	90.8	89.2	88.4	88.4	88.6	88.7	92.2
16	91.4	92.3	90.8	90.1	91.8	90.9	89.1	88.4	88.4	88.6	88.7	92.3
17	91.4	92.1	91.1	90.4	92.1	90.9	89.1	88.4	88.4	88.6	88.7	92.3
18	91.4	92.0	91.4	90.6	92.4	90.8	86.1	88.4	88.4	88.7	88.7	92.3
19	91.4	92.0	91.4	90.9	92.4	90.7	89.1	88.4	88.5	88.7	88.7	92.3
20	91.4	91.9	91.4	91.0	92.6	90.5	89.1	88.4	88.4	88.7	88.7	92.3
21	91.4	92.0	91.4	90.8	92.9	90.4	89.1	88.4	88.4	88.8	88.7	92.3
22	91.5	91.9	91.5	90.5	93.0	90.3	89.1	88.4	88.4	88.8	88.7	92.3
23	a92.4	91.8	a91.6	90.2	93.0	90.2	89.0	88.4	88.4	88.8	88.8	92.3
24	92.4	91.7	91.8	90.1	92.8	90.1	89.0	88.4	88.4	88.8	88.8	92.3
25	92.4	91.7	92.4	90.0	92.7	90.1	89.0	88.3	88.4	88.8	88.8	92.3
26	92.4	91.7	93.2	90.2	92.7	90.1	88.0	88.2	88.5	88.8	88.8	92.3
27	92.3	91.7	91.7	90.4	92.5	90.1	88.8	88.2	88.5	88.8	88.8	92.3
28	92.3	91.7	89.9	90.6	92.4	90.1	88.7	88.2	88.5	88.8	88.8	82.3
29	92.2	.....	89.5	90.6	92.3	90.1	88.7	88.2	88.5	88.8	88.8	92.3
30	92.1	.....	89.3	90.6	92.2	90.1	88.7	88.2	88.5	88.8	88.8	92.3
31	92.1	.....	89.2	.....	92.3	.....	88.7	88.2	.....	88.8	.....	92.1

a Ice readings Jan. 23 to Mar. 23, inclusive, and Dec. 1 to Dec. 31, inclusive.

SALESVILLE STATION ON WEST GALLATIN RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 123, is about 16 miles southwest of Bozeman, Montana, at the highway bridge crossing the stream about 5 miles south of Salesville. The old gage rod erected in July, 1895, is spiked to a tree. In September, 1896, a wire gage was placed on the bridge, the pulley being fastened to the end of the rod opposite the 0.15 foot mark. The distance of the end of the weight to the index marker is 15.50 feet. The two gages were made to read the same. The bed of the stream is rocky and the current is swift.

The bench mark for the wire gage is the head of the southwest bolt in the rim of the southeast cylindrical pier. Its elevation is 13.70 feet above datum. The observer is Ira T. Williams, Salesville, Montana. Discharge measurements were made during 1897, by Roe Emery, as follows:

May 9, gage height, 4.70 feet; discharge, 1,835 second-feet.
May 22, gage height, 6.70 feet; discharge, 5,538 second-feet.
June 5, gage height, 5.40 feet; discharge, 3,221 second-feet.
June 30, gage height, 4.55 feet; discharge, 1,858 second-feet.
July 19, gage height, 3.90 feet; discharge, 1,187 second-feet.
August 10, gage height, 3.50 feet; discharge, 869 second-feet.
September 10, gage height, 3.20 feet; discharge, 533 second-feet.
October 30, gage height, 3.20 feet; discharge, 491 second-feet.

Daily gage height, in feet, of West Gallatin River at Salesville, Montana, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Dec.
1	.....	4.15	6.70	4.50	3.60	3.20	3.20	.....
2	2.90	4.35	6.40	4.50	3.60	3.20	3.25	.....
3	2.90	4.65	5.90	4.65	3.50	3.20	3.30	.....
4	2.90	4.95	5.70	4.40	3.50	3.30	3.20	.....
5	2.90	5.15	5.60	4.50	3.50	3.20	3.20	.....
6	2.90	5.25	5.35	4.40	3.50	3.20	3.20	3.00
7	2.90	5.85	5.30	4.30	3.50	3.20	3.20	.....
8	2.90	5.75	5.20	4.40	3.50	3.20	3.20	.....
9	2.90	5.45	5.35	4.20	3.50	3.20	3.20	.....
10	2.95	4.85	5.70	4.15	3.50	3.20	3.20	.....
11	3.00	4.65	5.30	4.10	3.40	3.20	3.20	3.00
12	3.00	4.65	5.20	4.00	3.40	3.20	3.30	.....
13	2.90	5.15	5.20	4.00	3.40	3.20	3.30	.....
14	2.90	5.40	5.30	3.95	3.40	3.20	3.30	.....
15	3.05	5.75	5.30	3.90	3.30	3.20	3.20	2.90
16	3.10	6.15	5.25	3.90	3.20	3.20	3.20	.....
17	3.20	6.30	5.20	3.90	3.20	3.20	3.20	.....
18	3.35	6.30	5.00	3.90	3.20	3.20	3.20	.....
19	3.50	6.30	5.00	3.90	3.20	3.20	3.20	3.00
20	3.55	6.35	4.90	3.85	3.20	3.20	3.20	.....
21	3.40	6.85	4.70	3.80	3.20	3.20	3.20	.....
22	3.40	6.70	4.70	3.80	3.20	3.20	3.20	.....
23	3.45	6.20	4.70	3.85	3.20	3.20	3.20	.....
24	3.45	6.30	4.65	3.80	3.20	3.20	3.20	.....
25	3.40	6.80	4.55	3.80	3.20	3.20	3.20	.....
26	3.50	6.70	4.50	3.85	3.20	3.20	3.20	3.30
27	3.60	6.00	4.85	3.70	3.20	3.20	3.20	.....
28	3.95	6.00	4.50	3.65	3.20	3.20	3.20	.....
29	4.00	6.15	4.50	3.65	3.20	3.20	3.20	.....
30	3.95	6.30	4.45	3.60	3.20	3.20	3.20	.....
31	.....	6.80	.....	3.60	3.20	.....	3.20	.....

BOZEMAN STATION ON MIDDLE CREEK.

This station, described in the Eighteenth Annual Report, Part IV, page 127, is located in Middle Creek Canyon, 9 miles from Bozeman, Montana, and one-eighth of a mile above the old sawmill dam on the road from Bozeman. The gage is about half a mile upstream from the small footbridge which has been placed across the stream for convenience in making discharge measurements. It consists of a vertical post, 4 inches square, secured to a tree stump and protected by the latter from the full force of the current. The bench mark consists of a spike driven horizontally into a stump 5 feet high, about 80 feet east of the gage rod. The middle of this spike is at an elevation of 7.03 feet of the gage. Another bench mark consists of an 8-inch bridge spike driven horizontally into a charred stump about 25 feet northeast of the gage. The top of the spike is at an elevation of 3.58 feet. A third bench mark consists of a large rock 93 feet east of the gage, marked "B. M." in black paint. It is 4.84 feet above datum. Gage heights were not taken in 1897, owing to the impossibility of securing an observer at moderate expense. The following measurements were made during 1897 by Roe Emery:

May 3, gage height, 1.20 feet; discharge, 174 second-feet.
May 21, gage height, 1.20 feet; discharge, 340 second-feet.
June 4, gage height, 0.80 foot; discharge, 233 second-feet,
June 21, gage height, 0.70 foot; discharge, 184 second-feet.
July 6, gage height, 0.65 foot; discharge, 133 second-feet.
July 19, gage height, 0.50 foot; discharge, 108 second-feet.
August 1, gage height, 0.40 foot; discharge, 54 second-feet.
August 10, gage height, 0.30 foot; discharge, 44 second-feet.
September 20, gage height, 0.25 foot; discharge, 42 second-feet.

LOGAN STATION ON GALLATIN RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 128, is located at Logan, Montana, near the mouth of Gallatin River. The wire gage is placed in the east span of the railroad bridge and fastened to the guard rail on the upper side. The distance from the outside edge of the pulley to the end of the rod is 1 foot; from the end of the weight to the index marker 18.40 feet. Bench mark 1 is the top of the northeast corner of the iron plate at foot of diagonal end member of truss, east end, upper side, and is 13.70 feet above datum. Bench mark 2 consists of the head of a bridge spike driven vertically into the top of the pile stump, to which the lower end of the old inclined gage is fastened, and is 0.38 foot below the 2-foot mark on the gage. Discharge measurements are made from the cable across the river 300 feet above the railroad bridge. The section is a good one, the channel being straight for some distance above and below the cable. The bed is gravelly. The observer is James Martin. The following measurements were made by Roe Emery in 1897:

April 24, gage height, 1.50 feet; discharge, 930 second-feet.
May 4, gage height, 2.30 feet; discharge, 2,708 second-feet.
June 7, gage height, 3.30 feet; discharge, 3,811 second-feet.
July 3, gage height, 1.90 feet; discharge, 1,339 second-feet.
July 16, gage height, 0.70 foot; discharge, 555 second-feet.
July 31, gage height, 0.70 foot; discharge, 459 second-feet.
September 15, gage height, 0.90 foot; discharge, 526 second-feet.
October 6, gage height, 0.90 foot; discharge, 601 second-feet.

Daily gage height, in feet, of Gallatin River at Logan, Montana, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	(a)	.....	1.05	1.95	4.60	1.72	0.70	0.70	0.90	1.10	1.35
2	0.95	(a)	.....	1.20	2.00	4.20	1.80	.70	.70	1.15	1.10	1.40
3	.....	(a)	0.80	1.05	2.20	3.70	1.90	.70	.78	1.10	1.10	1.30
4	.....	(a)	.....	1.15	2.32	3.50	1.82	.70	.82	1.00	1.00	1.30
5	.....	(a)	.....	1.50	2.65	3.20	1.70	.70	.80	.90	1.00	1.20
6	1.25	(a)	.90	1.20	3.00	3.10	1.70	.70	.80	.90	1.00	1.10
7	.....	(a)	.....	1.10	3.20	3.10	1.65	.70	.80	.90	1.00	1.10
8	.....	(a)	.....	1.30	3.05	3.15	1.50	.70	.80	.90	1.00	1.10
9	1.20	(a)	.....	1.30	2.70	3.20	1.40	.70	.80	.90	1.00	1.00
10	.....	(a)	1.25	1.30	2.50	3.30	1.30	.70	.80	.90	1.00	1.00
11	.....	(a)	.....	1.30	2.25	3.00	1.20	.70	.80	1.00	1.10	1.00
12	.....	(a)	.....	1.50	2.35	3.00	1.10	.70	.80	1.00	1.10	1.00
13	1.30	(a)	.70	1.30	2.62	3.00	1.00	.70	.80	1.00	1.10	1.00
14	.....	(a)	.....	1.70	2.75	3.10	.90	.70	.80	1.00	1.10	1.00
15	.....	(a)	.....	1.90	3.15	3.00	.80	.70	.80	1.00	1.10	1.10
16	1.50	(a)	.....	1.90	3.45	2.90	.75	.70	.90	1.00	1.10	1.10
17	.....	(a)	.90	1.90	3.75	2.80	.70	.70	.90	1.00	1.10	1.00
18	.....	(a)	.....	1.90	3.85	2.70	.80	.70	.90	1.00	1.20	1.00
19	.....	(a)	.....	1.90	3.88	2.50	1.00	.70	.90	1.00	1.20	(a)
20	1.40	(a)	.95	1.70	4.10	2.40	.85	.70	.90	1.00	1.20	(a)
21	(a)	(a)	.....	1.60	4.28	2.30	.80	.70	.90	1.00	1.20	(a)
22	(a)	(a)	.....	1.50	4.10	2.20	.80	.70	.90	1.05	1.30	(a)
23	(a)	(a)	.....	1.50	3.95	2.20	.80	.70	.90	1.10	1.30	(a)
24	(a)	(a)	1.00	1.50	3.90	2.20	.80	.65	.90	1.10	1.20	(a)
25	(a)	(a)	.....	1.40	4.30	2.10	.78	.65	.90	1.10	1.20	(a)
26	(a)	(a)	.....	1.50	4.70	2.00	.70	.70	.90	1.10	1.10	(a)
27	(a)	0.95	1.80	1.60	3.95	2.00	.70	.70	.90	1.10	1.10	(a)
28	(a)	.....	.....	1.90	3.80	2.00	.70	.70	.90	1.10	1.10	(a)
29	(a)	.....	.....	1.95	3.85	2.00	.65	.70	.80	1.10	1.10	(a)
30	(a)	.....	.....	1.98	3.90	2.00	.60	.70	.80	1.10	1.20	(a)
31	(a)	.....	.....	.....	3.85	.....	.65	.70	.....	1.10	.....	1.63

a Frozen.

REDBLUFF STATION ON MADISON RIVER.

This station is located at the ranch of the observer, Mrs. S. A. Black, 4 miles below the Redbluff iron county bridge over the Madison, and about 1½ miles below the mouth of Cherry Creek. It is also about 3 miles below the location of the old Redbluff station, described in Bulletin No. 131, on page 18. It was established May 2, 1897, at which time the one at Threeforks was discontinued. The vertical gage is fastened to a post set firmly into the bed of the river, and braced with cross-pieces from the bank. Discharge measurements are made from the iron bridge above. Cherry Creek is measured at the same time as it enters between the gage and the bridge. The initial point for soundings is at the left abutment of the bridge. The banks are high and do not overflow. The bed of the stream is rocky and the current is quite swift. The following are the discharge measurements made during 1897 by Roe Emery:

Not including Cherry Creek:

April 27, gage height, 1.70 feet; discharge, 1,806 second-feet.
May 7, gage height, 2.45 feet; discharge, 2,803 second-feet.

Including Cherry Creek:

May 26, gage height, 3.70 feet; discharge, 8,467 second-feet.
June 19, gage height, 2.22 feet; discharge, 4,191 second-feet.
July 1, gage height, 1.90 feet; discharge, 2,794 second-feet.
July 14, gage height, 1.65 feet; discharge, 2,241 second-feet.
July 29, gage height, 1.50 feet; discharge, 2,115 second-feet.
September 14, gage height, 1.40 feet; discharge, 1,656 second-feet.
October 4, gage height, 1.50 feet; discharge, 1,940 second-feet.
November 2, gage height, 1.40 feet; discharge, 1,545 second-feet.

Daily gage height, in feet, of Madison River at Redbluff, Montana, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	3.75	1.92	1.60	1.40	1.40	17	2.75	2.50	1.88	1.40	1.40	1.30
2	2.08	3.65	1.92	1.60	1.40	1.40	18	(a)	2.30	1.85	1.40	1.40	1.30
3	2.08	3.55	2.00	1.60	1.40	1.40	19	(a)	2.25	1.80	1.40	1.40	1.35
4	2.15	3.35	2.00	1.60	1.40	1.40	20	(a)	2.25	1.85	1.40	1.40	1.40
5	2.22	3.20	2.00	1.60	1.40	1.40	21	(a)	2.10	1.80	1.40	1.40	1.40
6	2.35	2.50	1.90	1.50	1.40	1.40	22	(a)	2.05	1.70	1.40	1.40	1.40
7	2.45	2.40	2.00	1.50	1.40	1.40	23	(a)	2.10	1.82	1.40	1.40	1.40
8	2.50	2.50	2.00	1.45	1.40	1.40	24	(a)	2.00	1.85	1.40	1.40	1.50
9	2.35	2.60	1.95	1.40	1.40	1.40	25	(a)	2.00	1.70	1.40	1.40	1.50
10	2.28	2.55	1.90	1.40	1.40	1.40	26	(a)	2.00	1.70	1.40	1.35	1.50
11	2.15	2.40	1.90	1.40	1.40	1.40	27	3.75	1.94	1.75	1.40	1.35	1.50
12	2.10	2.30	1.90	1.40	1.40	1.40	28	3.60	1.93	1.70	1.40	1.40	1.50
13	2.15	2.30	1.80	1.40	1.40	1.40	29	3.40	1.90	1.70	1.40	1.40	1.50
14	2.35	2.40	1.80	1.40	1.40	1.40	30	3.45	1.90	1.70	1.40	1.40	1.50
15	2.45	2.45	1.82	1.40	1.40	1.40	31	3.55	.....	1.60	1.40	.....	.....
16	2.65	2.50	1.80	1.40	1.40	1.40							

a Over gage.

THREEFORKS STATION ON MADISON RIVER.

A description of this station was given in the Eighteenth Annual Report, Part IV, page 131. The gage is at the bridge of the Northern Pacific Railroad company, one-half mile from the town of Threeforks. The greater part of the discharge of the river flows under this bridge, but there are a number of small side channels, branching off at points above, through which considerable water flows, especially in time of flood. For this reason the station was discontinued on the 1st of May and one established at the Redbluff iron bridge, 30 miles above. A measurement was made June 8, 1897, which gave a discharge of 4,316 second-feet, at the same time the sloughs were discharging 1,568 second-feet additional. The gage is inclined, the zero being 14.11 feet below the top of the rail on the east end of the bridge.

Daily gage height, in feet, of Madison River at Threeforks, Montana, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	Day.	Jan.	Feb.	Mar.	Apr.	May.
1	.....	2.30	0.90	1.00	1.50	17	1.00	0.90	0.60	0.50	.....
2	.....	2.30	.90	1.00	.....	18	1.50	.90	.60	.50	.....
3	.....	2.30	.80	1.00	.....	19	1.40	.90	.60	.70	.....
4	.....	1.90	.80	2.00	.....	20	1.30	.99	.70	.70	.....
5	.....	2.00	.70	2.00	.....	21	1.20	.90	.70	.60	.....
6	.....	1.70	.70	1.05	.....	22	1.00	.90	.50	.60	.....
7	.....	1.30	.60	1.03	.....	23	.90	.90	.50	.70	.....
8	.....	1.30	.60	.50	.....	24	.90	.90	.40	.70	.....
9	.....	1.30	.60	.40	.....	25	1.00	.90	.40	.80	.....
10	2.00	1.20	.60	.40	.....	26	.80	.90	.30	.80	.....
11	1.51	1.20	.60	.50	.....	27	.80	.90	.20	.90	.....
12	2.25	1.00	.50	.55	.....	28	.80	.90	.80	1.00	.....
13	1.00	1.00	.50	.40	.....	29	.80	.....	.80	1.30	.....
14	2.00	.90	.60	.40	.....	30	.80	.....	.90	1.40	.....
15	1.00	.90	.60	.40	.....	31	1.30	.....	.90	.....	.....
16	1.00	.85	.60	.50	.....						

SAPPINGTON STATION ON JEFFERSON RIVER.

This station is described in the Eighteenth Annual Report, Part IV, page 134. The wire gage is fastened to the guard rail, on the upper side, in the east span of the Northern Pacific Railroad bridge, one-fourth of a mile north of Sappington station, Montana. The outside edge of the pulley is 0.2 foot from the end of the rod. The distance from the end of the weight to the index marker is 16 feet. Bench mark 1 consists of a 6-inch wire nail driven horizontally in the east side of the blocking which forms the south abutment of the railroad bridge, and is 6.9 feet on the gage. Bench mark 2 is a 6-inch wire nail driven horizontally into a telegraph pole about 30 feet south and east of the south abutment of the bridge, and is at an elevation of 7 feet on the gage. Bench mark 3 is the head of the northwest bolt fastening the switch standard to the cross-tie, 30 feet east of the bridge. Its elevation is 15.67 feet. On November 3, 1897, the rod was lowered 0.8 foot, by placing its end that distance nearer the pulley, thus making the pulley distance 0.2 foot, subsequent readings being adjusted to the old position. The

section is good, being straight for some distance above and below the cable. The bed of the river is gravelly. The observer is Clem Piper, storekeeper, address, Sand Creek, Montana. The following discharge measurements were made during 1897 by Roe Emery:

April 26, gage height, 2.60 feet; discharge, 3,571 second-feet.
May 6, gage height, 3.85 feet; discharge, 8,293 second-feet.
July 2, gage height, 2.10 feet; discharge, 3,321 second-feet.
July 15, gage height, 1.30 feet; discharge, 2,077 second-feet.
July 30, gage height, 0.80 foot; discharge, 1,116 second-feet.
September 14, gage height, 0.40 foot; discharge, 841 second-feet.
October 5, gage height, 0.50 foot; discharge, 920 second-feet.
Gage heights at Sappington; discharge measured at bridge at Three Forks:
May 27, gage height, 4.20 feet; discharge, 9,704 second-feet.
June 8, gage height, 2.65 feet; discharge, 4,638 second-feet.

Daily gage height, in feet, of Jefferson River at Sappington, Montana, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.00	2.95	3.65	2.10	0.70	—0.10	0.30	.....	.....
2	.....	3.10	3.75	2.00	.70	—.10	.30	.....	.....
3	.....	3.35	3.60	2.20	.60	—.10	.45	.....	.....
4	.....	3.50	3.40	2.35	.60	—.10	.50	.....	.....
5	.....	3.75	3.25	2.40	.60	+.10	.50	.....	.....
6	.....	4.00	3.05	2.30	.60	.20	.50	.60	1.60
7	.95	4.45	2.85	2.20	.50	.20	.50	.....	.....
8	.....	4.30	2.65	2.10	.50	.25	.50	.....	.....
9	.....	4.35	2.60	2.00	.50	.30	.50	.....	.....
10	1.00	3.95	2.60	2.00	.50	.30	.50	.....	.....
11	.....	3.60	2.45	1.85	.50	.20	.50	.....	.....
12	.....	3.35	2.25	1.65	.40	.30	.50	.....	1.00
13	.....	3.30	2.00	1.55	.40	.30	.50	.....	.....
14	1.00	3.45	1.90	1.40	.30	.40	.50	.60	.....
15	.....	3.55	1.85	1.25	.30	.40	.55	.....	.....
16	.....	3.80	1.90	1.20	.30	.40	.60	.....	.....
17	.....	3.95	2.10	1.05	.25	.40	.60	.....	.....
18	.....	4.30	2.25	1.10	.20	.40	.60	.....	.....
19	.....	4.50	2.30	1.20	.20	.40	.60	.....	1.80
20	3.90	4.50	2.25	1.20	.20	.40	.60	.....	.....
21	.....	4.50	2.15	1.15	.20	.40	.60	1.90	.....
22	.....	4.45	1.95	1.10	.....	.35	.65	.....	.....
33	.....	4.40	1.80	1.10	.....	.30	.70	.....	.....
24	.....	4.15	1.80	1.10	.....	.30	.80	.....	.....
25	.....	4.00	1.95	1.10	.....	.30	.80	.....	.....
26	2.60	4.05	2.00	1.05	.....	.30	.80	.....	(a)
27	3.00	4.20	1.95	1.00	.....	.30	.80	.....	.....
28	3.35	4.10	2.05	.95	—.10	.30	.80	1.90	.....
29	3.10	3.85	2.25	.85	—.10	.30	.70	.....	.....
30	3.05	3.65	2.20	.80	—.10	.30	.70	.....	.....
31	.....	3.40	.....	.70	—.10	.....	.....	.....	.....

a Frozen.

River frozen Jan. 1 to Apr. 1.

GREAT FALLS STATION ON SUN RIVER.

This station is located on Sun River, 10 miles above its mouth, at Great Falls, Montana. It is at the dam of the Priest Rapids Water Power and Irrigation system. The vertical rod with its zero corresponding to the crest of the dam is fastened to the north abutment. The observer is Mr. I. S. Corson, Great Falls, Montana. A discharge measurement made July 4, 1897, at the highway bridge 5 miles above the dam gave a discharge of 2,108 second-feet. On August 28 a measurement was made at the wagon bridge in the outskirts of West Great Falls about one-half mile above the junction of Sun and Missouri rivers. The gage height was 0.30 foot and the discharge 362 second-feet.

Daily gage height, in feet, of Sun River near Great Falls, Montana, for 1897.

Day.	July.	Aug.	Sept.	Oct.	Day.	July.	Aug.	Sept.	Oct.
1	.....	0.64	0.32	0.50	17	1.06	0.71	0.49	0.51
2	.....	.61	.32	.52	18	1.02	.72	.46	.50
3	.....	.62	.37	.50	19	.99	.62	.46	.50
4	.....	.64	.39	.49	20	.94	.60	.46	.51
5	.....	.66	.40	.50	21	.90	.58	.48	.54
6	.....	.65	.40	.49	22	.90	.52	.46	.54
7	.....	.66	.40	.49	23	.88	.50	.48	.52
8	.....	.67	.39	.49	24	.86	.48	.48	.51
9	.....	.68	.40	.50	25	.86	.44	.46	.52
10	.....	.68	.40	.50	26	.84	.39	.46	.53
11	1.07	.67	.42	.52	27	.82	.36	.46	.53
12	1.09	.66	.44	.52	28	.78	.32	.46	.53
13	1.06	.68	.43	.52	29	.73	.30	.46	.54
14	1.06	.68	.46	.50	30	.68	.30	.48	.53
15	1.04	.69	.48	.50	31	.64	.32	.....	.....
16	1.02	.69	.50	.52					

CHINOOK STATION ON MILK RIVER.

This station is located at the wagon bridge over Milk River, 1 mile south of Chinook, Montana. It was established May 25, 1897. The gage rod consists of a vertical timber, marked in feet and tenths, nailed to the south abutment of the bridge. The bench mark is the top of the inside tie rod directly over the gage and is at an elevation of 18.0 feet. The measurements at this point do not give the total discharge of the river, as quite a large canal, that of the Fort Belknap Irrigation Company, is taken out about 10 miles above the station. The observer is Fred E. Neill, rancher. Discharge measurements during 1897 were made by Roe Emery as follows:

May 25, gage height, 1.40 feet; discharge, 110 second-feet.
July 3, gage height, 2.30 feet; discharge, 460 second-feet.
November 10, gage height, 0.72 foot; discharge, 34 second-feet.

Daily gage height, in feet, of Milk River at Chinook, Montana, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	1.15	2.80	0.50	0.10	0.40	17	.....	8.95	1.90	0.30	0.40	0.50
2	.....	1.10	2.60	.50	.10	.40	18	.....	.....	1.80	.30	.60	.30
3	.....	1.30	2.20	.40	.10	.40	19	.....	8.00	1.60	.30	.60	.40
4	.....	1.30	2.00	.50	.10	.30	20	.....	7.00	1.40	.30	.70	.40
5	.....	1.20	2.30	.60	.10	.20	21	.....	6.40	1.00	.20	.70	.40
6	.....	1.10	2.40	.70	.10	.10	22	.....	5.30	.90	.20	.60	.30
7	.....	1.00	2.50	.60	.10	.40	23	.....	5.00	1.00	.20	.50	.30
8	.....	.90	2.60	.60	.10	.50	24	.....	4.00	1.10	.10	.40	.....
9	.....	.90	3.30	.50	.10	.60	25	1.40	3.40	1.00	.10	.30	.....
10	.....	.80	3.10	.40	.10	.40	26	1.60	3.00	.90	.10	.20	.....
11	.....	.80	3.00	.40	.10	.50	27	1.50	3.10	.80	.05	.20	.....
12	.....	1.00	2.80	.30	.10	.40	28	1.50	3.40	.70	.10	.30	.....
13	.....	.90	2.60	.20	.10	.40	29	1.50	3.00	.80	.10	.20	.....
14	.....	.80	2.20	.40	.10	.40	30	1.40	3.20	.60	.10	.20	.....
15	.....	.80	2.00	.30	.10	.60	31	1.20	.....	.60	.10	.....	.....
16	.....	1.40	1.80	.30	.20	.40							

LIVINGSTON STATION ON YELLOWSTONE RIVER.

This station is located at the highway bridge over the Yellowstone River, 5 miles south of Livingston, Montana, at the mouth of the canyon. It was established May 2, 1897, a vertical rod fastened to the face of the pier being first used. A wire gage was afterwards established. Length of cable 18.30 feet; pulley distance, 0.58 foot. The bench mark is the head of the 2-inch nut on the center pin at the foot of the end diagonal of the truss, east pier, upper side, and is 13.44 feet above datum. The left bank is high, and will not overflow. The right bank is low, and during floods a part of the water escapes through a slough on that side, and has to be measured separately. The observer is Thos. S. Carter, rancher. The following discharge measurements were made by Roe Emery during 1897:

April 30, gage height, 1.40 feet; discharge, 3,270 second-feet.
May 17, gage height, 4.50 feet; discharge, 14,127 second-feet.
June 15, gage height, 5.15 feet; discharge, 16,282 second-feet.
June 23, gage height, 4.50 feet; discharge, 13,209 second-feet.
July 8, gage height, 3.85 feet; discharge, 6,611 second-feet.
July 24, gage height, 3.00 feet; discharge, 5,971 second-feet.
August 4, gage height, 2.65 feet; discharge, 4,657 second-feet.
September 23, gage height, 1.40 feet; discharge, 2,121 second-feet.
November 8, gage height, 0.90 foot; discharge, 1,394 second-feet.

Daily gage height, in feet, of Yellowstone River at Livingston, Montana, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	6.70	3.98	2.80	1.88	1.30	1.10	.....
2	1.95	5.88	4.20	2.78	1.85	1.32	1.10	1.00
3	2.25	5.48	4.32	2.68	1.80	1.35	1.10	.....
4	2.60	5.10	4.20	2.68	1.80	1.30	1.05	.....
5	3.05	4.90	4.00	2.70	1.80	1.30	1.05	.....
6	3.40	4.75	3.92	2.68	1.75	1.30	1.10	.....
7	3.75	4.60	3.85	2.70	1.75	1.30	.....	.....
8	3.52	4.90	3.82	2.65	1.75	1.25	.....	.....
9	3.00	5.32	3.72	2.65	1.70	1.25	.....	.....
10	2.68	5.12	3.62	2.65	1.68	1.25	.....	.....
11	2.58	4.94	3.50	2.65	1.60	1.25	.....	.....
12	2.72	5.02	3.50	2.60	1.60	1.30	1.20	.....
13	3.02	5.30	3.40	2.55	1.60	1.40	.....	.....
14	3.70	5.32	3.45	2.48	1.58	1.45	.....	.90
15	4.22	5.18	3.43	2.40	1.60	1.40	.....	.....
16	4.48	5.12	3.35	2.38	1.58	1.30	.....	.....
17	4.55	4.90	3.33	2.33	1.55	1.30	.....	.....
18	4.80	4.70	3.30	2.30	1.50	1.30	.....	.40
19	4.95	4.50	3.18	2.28	1.50	1.30	1.10	.....
20	5.75	4.45	3.15	2.20	1.45	1.25	.....	.....
21	6.10	4.45	3.10	2.20	1.45	1.25	.....	.....
22	6.05	4.45	3.08	2.15	1.40	1.25	.....	.....
23	5.85	4.45	3.03	2.13	1.40	1.25	.....	.....
24	5.78	4.38	3.05	2.10	1.40	1.28	.....	.70
25	6.10	4.30	3.10	2.08	1.38	1.25	.....	.....
26	6.10	4.30	3.05	2.05	1.35	1.25	1.00	.....
27	5.60	4.30	3.05	2.00	1.35	1.18	.....	.....
28	5.55	4.28	2.98	2.00	1.35	1.12	.....	.....
29	5.65	4.02	2.88	1.95	1.32	1.12	.....	.....
30	6.02	3.98	2.85	1.95	1.30	1.15	.....	.....
31	5.95	.....	2.85	1.90	.....	1.15	.....	.85

MISCELLANEOUS DISCHARGE MEASUREMENTS IN MONTANA.

During 1897 a number of discharge measurements shown below were made on streams in the immediate vicinity of Bozeman, Montana, by Roe Emery and others, at points where no gage rods were established:

Bozeman Creek.—May 12, discharge, 91 second-feet; May 29, discharge, 60 second-feet; June 22, discharge, 21 second-feet; July 10, discharge, 21 second-feet; July 23, discharge, 30 second-feet; August 9, discharge, 21 second-feet; September 7, discharge, 21 second-feet; September 27, discharge, 12 second-feet.

Rocky Creek.—May 12, discharge, 143 second-feet; May 29, discharge, 74 second-feet; June 22, discharge, 38 second-feet; July 10, discharge, 23 second-feet; July 25, discharge, 24 second-feet; August 9, discharge, 15 second-feet; September 11, discharge, 12 second-feet.

Shields River.—These measurements were made at the bridge near the mouth of the river, 5 miles east of Livingston: May 17, discharge, 1,708 second-feet; June 15, discharge, 883 second-feet; June 23, discharge, 722 second-feet; July 8, discharge, 798 second-feet; July 24, discharge, 315 second-feet; August 5, discharge, 117 second-feet; September 22, discharge, 59 second-feet.

MEETEETSE STATION ON GREY BULL RIVER.

This station is located at the highway bridge in the town of Meeteetse, Wyoming. The rod is fastened to the first pier from the south bank of the river. The bed of the river is of sandstone and but few places can be found on the stream where the water is not a torrent during May and June. The channel is straight. The rod was established by J. E. Hill in May, 1897. A. C. Thomas is the observer.

The following discharge measurements were made by Elwood Mead and C. T. Johnston during 1897:

June 11, gage height, 4.70 feet; discharge, 1,435 second-feet.
August 23, gage height, 2.60 feet; discharge, 147 second-feet.
August 26, gage height, 2.65 feet; discharge, 158 second-feet.

Daily gage height, in feet, of Grey Bull River at Meeteetse, Wyoming, for 1897.

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1	.....	3.50	3.30	2.30	17	3.80	3.35	2.90	2.50
2	.....	4.95	3.30	2.30	18	3.50	3.35	2.90	2.50
3	.....	3.80	3.40	2.30	19	3.30	3.05	2.90	2.50
4	.....	3.70	3.30	2.20	20	3.40	3.15	2.80	2.50
5	.....	3.70	3.60	2.10	21	4.10	3.10	2.80	2.40
6	.....	3.60	3.30	2.10	22	4.30	3.05	2.70	2.40
7	.....	3.60	3.20	2.00	23	4.50	3.10	2.70	2.30
8	.....	3.50	3.40	2.00	24	4.10	3.10	2.90	2.20
9	.....	3.50	3.30	2.00	25	4.30	3.25	2.80	2.10
10	.....	3.40	3.50	1.90	26	4.30	3.25	2.70	2.10
11	.....	3.30	3.20	1.90	27	4.10	3.20	2.60	2.20
12	.....	3.50	3.20	2.30	28	4.00	2.95	2.50	2.20
13	.....	3.50	3.30	2.40	29	3.10	3.15	2.40	2.30
14	4.70	3.40	3.10	2.50	30	3.50	3.10	2.40	2.30
15	4.80	3.50	3.00	2.50	31	.....	3.50	2.30	.....
16	4.60	3.55	3.00	2.50					

LOVELL STATION ON SHOSHONE RIVER.

This station is located at Lovell, Wyoming, and was established May 23, 1897. The observer is Henry Cockrell. The rod is securely fastened to the landing pier of the Lovell ferry on the south side of the river. The channel is straight for some distance above and below the rod and a cross section there has a uniform depth. The bed of the river is stable.

The following discharge measurements were made by Elwood Mead and C. T. Johnston in 1897:

May 24, gage height, 2.70 feet; discharge, 8,736 second-feet.
June 2, gage height, 2.40 feet; discharge, 7,310 second-feet.
September 15, gage height, —0.70 foot; discharge, 363 second-feet.

Daily gage height, in feet, of Shoshone River at Lovell, Wyoming, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	3.00	1.50	0.30	—0.70	—0.70	17	.....	2.00	1.20	—0.30	—0.70	.....
2	.....	2.40	1.90	.10	—.70	—.70	18	.....	1.40	.90	—.40	—.70	.....
3	.....	1.80	1.90	.10	—.70	—.70	19	.....	1.00	.60	—.40	—.70	.....
4	.....	1.40	1.50	.10	—.70	—.70	20	.....	1.20	.40	—.40	—.70	.....
5	.....	1.20	1.00	.10	—.70	—.70	21	.....	1.80	.20	—.50	—.70	.....
6	.....	1.10	.80	.00	—.70	—.70	22	.....	1.70	.30	—.60	—.70	.....
7	.....	1.00	.80	.00	—.70	—.70	23	2.70	2.00	.50	—.50	—.70	.....
8	.....	1.70	1.30	—.10	—.70	—.70	24	2.85	1.80	.40	—.50	—.70	.....
9	.....	2.70	1.00	—.10	—.70	—.70	25	2.70	1.70	.30	—.60	—.70	.....
10	.....	2.10	.90	—.10	—.70	—.70	26	2.70	1.90	.20	—.60	—.70	.....
11	.....	2.00	1.10	.00	—.70	—.70	27	2.10	1.90	.30	—.60	—.70	.....
12	.....	2.30	.90	—.10	—.70	—.70	28	2.10	1.50	.20	—.60	—.70	.....
13	.....	2.50	1.10	—.20	—.70	—.70	29	2.50	1.30	.10	—.60	—.70	.....
14	.....	2.60	1.30	—.20	—.70	—.60	30	.....	1.40	.20	—.60	—.70	.....
15	.....	2.70	1.20	—.30	—.70	—.50	31	.....	.....	.40	—.60	.....	.....
16	.....	2.80	1.00	—.30	—.70	—.70							

SHERIDAN STATIONS ON BIG AND LITTLE GOOSE CREEKS.

These stations are described in the Eighteenth Annual Report, Part IV, pages 136 and 137. The gage on Little Goose Creek is located at Broadway bridge in the town of Sheridan, Wyoming, and about 1,000 feet above the mouth of the creek. The gage rod is firmly fastened to the piles of the bridge. The channel is shifting, being composed of clay and gravel.

The station on Big Goose Creek is located in the northern part of Sheridan, at the Fifth avenue bridge crossing. The rod is securely fastened to the bridge piles and protected from injury by driftwood or ice. The channel is shifting, composed of clay and gravel. The station is below the mouth of Little Goose Creek. The observer for both stations is Felix O'Connor. No measurements of discharge were made of either creek in 1897.

Daily gage height, in feet, of Big Goose Creek at Sheridan, Wyoming, for 1897.

Day.	May.	June.	July.	Aug.	Day.	May.	June.	July.	Aug.
1	.....	3.60	2.50	1.35	17	.....	3.10	1.65	.....
2	.....	3.90	2.45	1.35	18	.....	2.85	1.65	.....
3	.....	3.25	2.40	.....	19	.....	2.65	1.65	.....
4	.....	3.25	2.35	.....	20	.....	2.35	1.65	.....
5	.....	3.10	2.25	.....	21	4.65	2.35	1.65	.....
6	.....	2.90	2.25	.....	22	5.00	2.35	1.65	.....
7	.....	3.05	2.15	.....	23	4.10	2.40	1.60	.....
8	.....	3.15	2.15	.....	24	3.70	2.40	1.60	.....
9	.....	3.40	2.15	.....	25	4.65	2.40	1.60	.....
10	.....	3.40	2.20	.....	26	4.05	2.40	1.60	.....
11	.....	3.15	2.15	.....	27	3.55	2.35	1.60	.....
12	.....	3.15	2.15	.....	28	3.35	2.35	1.50	.....
13	.....	3.30	2.15	.....	29	3.25	2.35	1.50	.....
14	.....	3.15	1.65	.....	30	4.50	2.40	1.40	.....
15	.....	3.05	1.65	.....	31	3.50	.....	1.40	.....
16	.....	3.05	1.65	.....					

Daily gage height, in feet, of Little Goose Creek at Sheridan, Wyoming, for 1897.

Day.	May.	June.	July.	Aug.	Day.	May.	June.	July.	Aug.
1	.....	2.10	1.20	1.00	17	.....	1.60	1.00	.....
2	.....	2.25	1.15	1.00	18	.....	1.25	1.00	.....
3	.....	2.00	1.00	.....	19	.....	1.00	1.00	.....
4	.....	1.95	1.00	.....	20	.....	1.10	1.00	.....
5	.....	2.10	1.00	.....	21	3.05	1.35	1.00	.....
6	.....	1.70	1.00	.....	22	3.00	1.10	1.00	.....
7	.....	2.05	1.00	.....	23	2.55	1.10	1.00	.....
8	.....	2.10	1.00	.....	24	2.40	1.00	1.00	.....
9	.....	2.35	1.00	.....	25	2.35	1.00	1.00	.....
10	.....	2.15	1.00	.....	26	2.40	1.00	1.05	.....
11	.....	2.05	1.00	.....	27	2.40	1.00	1.00	.....
12	.....	2.00	1.00	.....	28	2.50	1.00	1.00	.....
13	.....	2.00	1.00	.....	29	2.60	1.20	1.00	.....
14	.....	1.60	1.00	.....	30	2.00	1.00	1.00	.....
15	.....	1.35	1.00	.....	31	2.00	.....	1.00	.....
16	.....	1.35	1.00	.....					

BUFFALO STATION ON CLEAR CREEK.

This station, described in the Eighteenth Annual Report, Part IV, page 138, is located about 4 miles west of Buffalo, Wyoming, the county seat of Johnson County, on what was formerly the Fort McKinney Military Reservation. The observer is Fred Bond. Measurements were begun in 1889, in which year a substantial measuring flume was placed in the channel of the stream. This flume is 24 feet long, 30 feet wide, with sides 7 feet high, and with wings at the sides and a pitched apron at the upper end 12 feet long. The floor is set level in all directions, the upstream edge being even with the grade of the creek channel, and the lower 3 or 4 inches above. It cost $300, and although subjected to rough usage through the practice of floating cord wood and timber down the stream, it is still uninjured, and permits of more accurate measurements than can be obtained at any other gaging station in the State. The following discharge measurements were made by Fred Bond during 1897:

January 3, gage height, 0.35 foot; discharge, 20 second-feet.
February 7, gage height, 0.30 foot; discharge, 17 second-feet.
March 10, gage height, 0.40 foot; discharge, 25 second-feet.

Daily gage height, in feet, of Clear Creek, at Buffalo, Wyoming, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1			2.22	1.30	0.65	0.50			
2		1.22	1.80	1.15	.60	.50			
3		1.22	1.54	1.05	.65	.50			
4		1.33	1.42	.95	.65	.50			
5		1.45	1.40	1.00	.65				
6		1.56	1.47	1.05	.65			0.40	0.45
7		1.93	1.28	1.05	.70		0.45		
8		1.79	1.38	1.00	.70				
9		1.51	1.57	1.00	.70				
10		1.33	1.49	.90	.75				
11		1.22	1.39	.90	.80				
12		1.17	1.36	.90	.75			.45	.40
13		1.20	1.28	.90	.70				
14		1.25	1.29	.90	.70				
15		1.44	1.30	.90	.70				
16		1.57	1.30	.90	.70				
17	1.35	1.60	1.30	.85	.65		.45		
18		1.69	1.30	.85	.65				
19		1.86	1.30	.90	.65			.45	
20		1.35	1.30	.90	.65			.60	
21		2.16	1.30	.95	.60			.60	
22		1.89	1.15	.90	.60			.60	
23		1.68	1.20	.95	.60			.50	
24		1.71	1.40	.95	.60		.50		
25		1.93	1.35	.90	.55				.40
26		1.97	1.30	.85	.55				
27	1.15	1.70	1.25	.75	.55				
28		1.54	1.20	.75	.55				
29		1.56	1.25	.70	.55				
30		1.56	1.30	.65	.55			.40	
31		1.62		.65	.55		.40		.40

CRAWFORD STATION ON WHITE RIVER.

This station is about 6 miles southwesterly from Crawford, Nebraska, near the line of the Fremont, Elkhorn and Missouri Valley Railroad. It was established on June 26, 1897, by O. V. P. Stout. The gage is placed against a stop gate in the canal of the Crawford Water Power and Irrigation Company, about one-eighth of a mile below the head. All the water of White River is diverted into this canal, and only an insignificant amount escapes between the head of the canal and the gage. The gage was placed by the canal company and is a vertical rod graduated to tenths of a foot. The observer is George Barclay, ditch rider for the canal company. Discharge measurements were made by O. V. P. Stout and A. B. McCoskey in 1897, as follows:

June 26, gage height. 0.42 foot; discharge, 14.4 second-feet.
July 21, gage height, 0.62 foot; discharge, 14.2 second-feet.
August 14, gage height, 0.60 foot; discharge, 12.1 second-feet.
September 6, gage height, 0.40 foot; discharge, 8.9 second-feet.
September 20, gage height, 0.62 foot; discharge, 10.4 second-feet.
September 21, gage height, 0.64 foot; discharge, 11 second-feet.
October 18, gage height, 0.89 foot; discharge, 15 second-feet.
November 5, gage height, 0.92 foot; discharge, 16 second-feet.

Daily gage height, in feet, of White River at Crawford, Nebraska, for 1897.

Day.	July.	Aug.	Sept.	Oct.	Day.	July.	Aug.	Sept.	Oct.
1		0.40	0.40	0.71	17	0.30	0.60	0.70	0.90
2		.40	.40	.70	18	.55	.60	.62	.89
3		.60	.40	.70	19	.80	.60	.68	.87
4		.70	.40	.75	20	.70	.50	.60	.89
5		.70	.40	.73	21	.60	.50	.63	.90
6		.70	.43	.76	22	.55	.55	.68	.90
7		.60	.40	.77	23	.55	.50	.65	.88
8		.60	.43	.76	24	.50	.50	.68	.88
9		.70	.50	.68	25	.65	.50	.69	.82
10		.70	.63	.73	26	.55	.40	.70	.82
11		.70	.65	.75	27	.55	.45	.69	.82
12		.60	.70	.82	28	.65	.40	.69	.91
13	0.40	.55	.65	.86	29	.50	.40	.69	.91
14	.30	.60	.63	.82	30	.50	.45	.70	.91
15	.40	.60	.63	.84	31	.45	.45		
16	.35	.60	.60	.81					

FORT NIOBRARA STATION ON NIOBRARA RIVER.

This station was established July 22, 1897, by O. V. P. Stout. It is about three-quarters of a mile southwesterly from Fort Niobrara and about 3 miles east of Valentine, Nebraska. The gage is an oak rod 2 by 4 inches, graduated to tenths of a foot, and fastened in a vertical position by lag screws to a plumb post in the trestle bent which serves as the west pier of the bridge. The zero of the gage is 9.08 feet below the top of the short cap, at the shoe of the north truss at the west end of the bridge; it is also 8.09 feet below the top of the north end of the long pile cap, below the cap above noted; and also 9.17 feet lower than the top of the west side of the iron cap of the north cylinder of the center pier of the bridge. The observer is Giacomo Bevilaqua, private, Company F, Twelfth United States Infantry. Discharge measurements were made by O. V. P. Stout and Adna Dobson in 1897, as follows:

June 24, gage height, 0.59 foot; discharge, 925 second-feet.
July 22, gage height, 0.48 foot; discharge, 883 second-feet.
August 15, gage height, 0.38 foot; discharge, 703 second-feet.
September 5, gage height, 0.46 foot; discharge, 730 second-feet.
October 16, gage height, 0.21 foot; discharge, 845 second-feet.

Daily gage height, in feet, of Niobrara River at Fort Niobrara, Nebraska, for 1897.

Day.	July.	Aug.	Sept.	Oct.	Day.	July.	Aug.	Sept.	Oct.
1		0.33	0.41	0.42	17		0.39	0.41	0.17
2		.30	.38	.40	18		.32	.37	.20
3		.45	.36	.40	19		.31	.39	.15
4		.41	.41	.40	20		.31	.36	.14
5		.50	.40	.40	21		.39	.38	.12
6		.50	.41	.38	22	0.51	.39	.45	.19
7		.46	.39	.35	23	.46	.38	.45	.22
8		.47	.34	.30	24	.50	.34	.46	.23
9		.40	.45	.31	25	.44	.31	.48	.28
10		.50	.47	.32	26	.41	.32		.37
11		.34	.45	.32	27	.44	.32		.29
12		.40	.45	.26	28	.44	.32		.22
13		.36	.49	.27	29	.44	.31	.45	.15
14		.37	.50	.23	30	.40	.32	.44	.12
15		.36	.42	.21	31	.40	.39		
16		.29	.45	.20					

WOODS LANDING STATION ON LARAMIE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 145, is located at Woods Landing, Wyoming, 26 miles from Laramie, Wyoming, and reached by stage. The measurements of discharge are made from a wagon bridge which spans the river at a point about 400 feet below the location of the gage rod. The bottom of the stream is composed of large granite bowlders. This character of bottom, while it renders the shape and slope of channel practically unchangeable, at the same time adds an element of uncertainty to the gaging results, especially at low-water stages. The permanent gage rod is fixed to a perpendicular post set firmly in the bed of the stream and braced at the top to adjacent trees. It stands about 4 feet from the river bank in a position which protects it from drift. The bench mark is a nail head in a notch on a cottonwood tree, 1 foot in diameter, 6 feet from the rod, and is level with the 7-foot mark on the rod. The observer is S. S. Wood. The following discharge measurements were made by C. T. Johnston in 1897:

April 10, gage height, 0.70 foot; discharge, 69 second-feet.
May 12, gage height, 2.30 feet; discharge, 1,110 second-feet.
May 25, gage height, 4.10 feet; discharge, 3,538 second-feet.
June 1, gage height, 3.60 feet; discharge, 2,509 second-feet.
June 2, gage height, 3.75 feet; discharge, 2,651 second-feet.
June 14, gage height, 2.65 feet; discharge, 1,432 second-feet.
June 26, gage height, 2.00 feet; discharge, 707 second-feet.
June 27, gage height, 2.00 feet; discharge, 706 second-feet.

Daily gage height, in feet, of Laramie River at Woods Landing, Wyoming, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Day.	Apr.	May.	June.	July.	Aug.	Sept.
1....	0.50	1.65	3.70	1.70	0.95	0.70	17.....	.85	3.05	2.95	1.30	0.80	0.60
2....	.50	1.75	3.70	1.70	.90	.70	18.....	1.00	3.15	2.75	1.50	.80	.60
3....	.45	1.85	3.65	1.60	.95	.70	19.....	1.10	3.30	2.55	1.50	.80	.60
4....	.50	2.05	3.55	1.50	1.15	.70	20.....	1.20	3.55	2.45	1.40	.80	.60
5....	.45	2.30	3.20	1.40	1.00	.70	21.....	1.25	3.70	2.35	1.30	.80	.60
6....	.60	2.65	2.85	1.35	1.00	.70	22.....	1.10	3.80	2.25	1.25	.70	.60
7....	.60	2.85	2.65	1.30	.90	.70	23.....	1.05	3.90	2.20	1.20	.70	.60
8....	.60	2.95	2.65	1.30	.90	.70	24.....	1.05	3.85	2.10	1.10	.70	.60
9....	.60	2.90	2.90	1.40	1.00	.70	25.....	1.00	4.05	2.00	1.00	.70	.60
10....	.60	2.85	3.20	1.50	1.00	.70	26.....	1.20	3.95	2.00	1.00	.70	.60
11....	.70	2.45	3.15	1.60	.90	.70	27.....	1.35	3.90	2.00	1.10	.70	.60
12....	.70	2.25	3.25	1.50	.90	.70	28.....	1.40	3.80	2.00	1.10	.70	.60
13....	.75	2.40	3.15	1.45	.80	.70	29.....	1.45	3.75	1.85	1.00	.70	.60
14....	.85	2.55	3.05	1.40	.80	.70	30.....	1.50	3.65	1.80	1.00	.70	.60
15....	.90	2.65	3.15	1.30	.80	.70	31.....	.....	3.75	.....	1.00	.70	.....
16....	.90	2.90	3.05	1.30	.80	.70							

UVA STATION ON LARAMIE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 148, is on the line of the Cheyenne Northern Railway, about 1 mile from the town of Uva, Wyoming. The observer is the railway section man, J. A. Carley. The rod is fixed to the side of one of the cluster of piles in mid-channel which supports the railroad bridge. As the section here is not a suitable place to make the discharge measurements, they are made at the wagon bridge which crosses the stream with one clear span about 1,000 feet below the railroad bridge. Here the river has a sufficient straight stretch above and below the bridge to insure a uniform current. The bed of the river is sandy and liable to change during high water. The bench mark is a spike head on south side of pile at east end of railroad bridge. It is 11.95 feet above zero of gage. The following discharge measurements were made by C. T. Johnston in 1897:

April 12, gage height, 1.85 feet; discharge, 205 second-feet.
May 4, gage height, 3.00 feet; discharge, 830 second-feet.
May 14, gage height, 3.10 feet; discharge, 748 second-feet.
May 15, gage height, 3.00 feet; discharge, 742 second-feet.
May 21, gage height, 3.70 feet; discharge, 1,160 second-feet.
May 29, gage height, 5.15 feet; discharge, 2,432 second-feet.
June 8, gage height, 4.05 feet; discharge, 1,365 second-feet.
June 19, gage height, 3.35 feet; discharge, 817 second-feet.
June 22, gage height, 2.45 feet; discharge, 500 second-feet.
July 10, gage height, 1.05 feet; discharge, 44 second-feet.

Daily gage height, in feet, of Laramie River at Uva, Wyoming, for 1897.

Day.	Jan.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	2.60	3.00	4.90	1.50	0.80	0.80	0.60
2	1.50	2.60	3.20	5.00	1.40	.70	.80	.60
3	.....	3.70	3.10	5.20	1.40	1.00	.80	.....
4	.....	3.60	3.00	5.00	1.30	2.00	.70	.....
5	.....	3.60	3.00	4.10	1.20	2.40	.70	.....
6	.....	2.40	3.20	4.80	1.00	1.60	.70	.....
7	1.50	1.80	3.20	4.80	1.00	1.50	.65	.....
8	.....	1.70	3.10	4.40	.90	1.40	.65	.....
9	.....	1.60	2.90	3.80	.90	1.40	.65	.....
10	.....	1.60	3.20	3.40	.90	1.40	.65	.....
11	.....	1.50	3.30	3.30	1.00	2.60	.65	.....
12	.....	1.70	3.50	3.70	1.00	2.40	.65	.....
13	.....	1.80	3.30	4.10	1.00	2.00	.60	.....
14	.....	1.80	3.20	3.80	1.00	1.60	.60	.....
15	1.30	1.80	3.00	3.80	.90	1.40	.55	.....
16	.....	2.00	2.90	3.70	.90	1.20	.55	.....
17	.....	2.00	3.00	3.60	.90	1.10	.55	.....
18	.....	4.30	2.90	3.30	.90	1.10	.60	.....
19	.....	4.00	3.10	2.80	.90	1.00	.60	.....
20	.....	4.10	3.20	2.80	.90	1.00	.65	.....
21	.....	4.40	3.60	2.80	.90	1.00	.65	.....
22	.....	4.00	4.10	2.60	.90	1.00	.65	.....
23	.....	3.90	4.70	2.30	.90	1.00	.60	.....
24	.....	3.70	4.90	2.00	.90	1.00	.60	.....
25	.....	3.40	5.10	1.90	.80	1.00	.60	.....
26	.....	3.10	5.20	1.50	.80	.90	.60	.....
27	.....	3.00	5.30	1.70	.80	.90	.60	.....
28	.....	3.00	5.30	1.60	.80	.90	.60	.....
29	.....	2.90	5.20	1.60	.80	.90	.57	.....
30	.....	3.00	4.10	1.50	.80	.80	.57	.....
31	.....	.....	4.80	.....	.90	.80	.....	.....

ORIN JUNCTION STATION ON NORTH PLATTE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 150, is located at the bridge of the Cheyenne Northern Railway, near Orin Junction, Wyoming. The rod is fixed upon the mid-channel pier of the railway bridge, and is connected with the following permanent bench mark: Spike on top of cap on the set of piles nearest the water at east end of bridge is 11.52 feet above datum. The bed of the stream is composed of heavy gravel and sand, the cross section being quite uniform. The channel is straight for some distance above and below the station. The section boss, P. J. Burns, is employed as observer. The stream at this station is divided into two permanent main channels by the bridge pier, and at high water there is a third channel to the west of the second pier across which the bridge rests on piles, and at a certain stage of water a long cobble bar running down to the bridge divides this third channel into two, thus making at times four channels altogether. The following discharge measurements were made in 1897 by C. T. Johnston:

April 13, gage height, 2.57 feet; discharge, 1,710 second-feet.
May 3, gage height, 5.50 feet; discharge 8,751 second-feet.
May 13, gage height, 5.40 feet; discharge, 10,434 second-feet.
May 20, gage height, 5.90 feet; discharge, 13,471 second-feet.
May 28, gage height, 6.60 feet; discharge, 16,320 second-feet.
June 7, gage height, 5.55 feet; discharge, 11,622 second-feet.
June 18, gage height, 5.25 feet; discharge, 10,100 second-feet.
June 21, gage height, 4.90 feet; discharge, 8,424 second-feet.

Daily gage height, in feet, of North Platte River at Orin Junction, Wyoming, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1				2.88	5.68	6.45	3.38		0.72
2	1.90			2.78		6.18	3.35	1.40	.70
3				2.68	5.52	6.40	3.22	1.32	.70
4					5.60	7.00		1.78	.70
5				2.62	5.68	6.90	3.30	1.75	
6		2.05	2.30	2.52	5.78		3.32	1.78	.70
7				2.42	5.98	5.45	3.32	2.62	.70
8	1.60			2.32	6.12	5.15	3.15		.70
9				2.25		4.95	2.90	2.08	.62
10				2.20	6.20	4.75	2.65	2.08	.60
11					6.10	4.65		2.00	.60
12				2.42	5.90	5.10	2.42	1.88	
13		2.05	2.40	2.55	5.55		2.32	1.78	.82
14				2.68	5.32	5.50	2.30	2.15	.78
15	1.50			2.78	5.15	5.35	2.20		.68
16				3.12		5.35	2.28	1.78	.58
17				3.32	5.32	5.25	2.18	1.52	.50
18					5.60	5.25		1.45	.50
19				4.48	5.85	5.00	2.42	1.35	.65
20		2.20	2.70	4.65	5.98		2.32	1.30	.62
21				5.25	6.08	4.30	2.15	1.22	.62
22				5.90	6.25	4.15	2.02		.60
23	1.75			5.85		3.98	2.00	1.12	.60
24				5.50	6.60	3.88	2.00	1.02	.60
25					6.85	3.80		.92	.60
26				4.48	7.00	3.80	1.92	.82	
27		2.15	1.65	4.68	7.18		1.82	.80	.65
28	1.75			4.90	7.20	3.73	1.72	.88	.65
29				5.35	7.05	3.60	2.62		.65
30				5.58		3.48	2.52	.80	.52
31			3.15		6.78		1.42	.78	

GERING STATION ON NORTH PLATTE RIVER.

This station is located about 1 mile north of Gering, Nebraska, and was established May 29, 1897, by A. B. McCoskey, assistant State engineer. The gage is on the west side of the bridge within a few feet of the south edge of the main channel of the river, and is a vertical rod graduated to tenths of a foot, and fastened to the bridge pile. The zero of the gage is 6.61 feet below a nail head on top of the west end of the first cap at the south end of the bridge. The observer is C. D. Snyder, who is manager of the mill near the gage. Discharge measurements were made in 1897 by O. V. P. Stout and A. B. McCoskey as follows:

May 29, gage height 3.28 feet; discharge, 23,364 second-feet.
September 11, gage height 0.90 foot; discharge, 500 second-feet.
November 2, gage height 1.02 feet; discharge, 661 second-feet.

Daily gage height, in feet, of North Platte River at Gering, Nebraska, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	3.00	1.80	1.20	1.10	0.80	17	.....	.....	1.30	1.40	0.90	0.95
2	.....	3.00	1.80	1.10	1.10	.80	18	.....	.....	1.40	1.30	.90	.95
3	.....	3.12	1.80	1.10	1.10	.80	19	.....	.....	1.50	1.20	.90	.95
4	.....	3.30	1.70	1.20	1.00	.80	20	.....	.....	1.30	1.20	.90	.95
5	.....	3.35	1.70	1.10	1.00	.80	21	.....	.....	1.30	1.10	.90	.95
6	.....	.....	1.60	1.10	1.00	.80	22	.....	.....	1.30	1.10	.85	.95
7	.....	.....	1.50	1.10	1.00	.80	23	.....	.....	1.30	1.00	.85	.95
8	.....	.....	1.50	1.30	.90	.80	24	.....	.....	1.30	1.00	.85	1.00
9	.....	.....	1.60	1.30	.90	.80	25	.....	.....	1.30	1.00	.85	1.00
10	.....	.....	1.70	1.50	.90	.85	26	.....	.....	1.30	.90	.85	1.00
11	.....	.....	1.50	1.30	.90	.85	27	.....	.....	1.30	.90	.85	.95
12	.....	.....	1.40	1.30	.90	.85	28	.....	.....	1.30	.90	.85	.95
13	.....	.....	1.40	1.30	.90	.90	29	.....	.....	1.30	.90	.80	.95
14	.....	.....	1.30	1.40	.90	.90	30	3.50	.....	1.20	.90	.80	.95
15	.....	.....	1.30	1.40	.90	.90	31	3.30	.....	1.20	.90	.....	.....
16	.....	.....	1.30	1.40	.90	.90							

CAMP CLARKE STATION ON NORTH PLATTE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 153, is located on the right bank of the river, about 40 feet above the bridge at Camp Clarke, Nebraska. The observer is Robert H. Willis, county surveyor of Cheyenne County, Nebraska, who lives about 1 mile from the gage. The gage consists of an oak piece, 2 by 4 inches, 10 feet long. It is fastened to cross-ties, which are bedded in the bank of the river. The face of the rod is inclined at an angle of 30 degrees to the horizontal, so that 2 feet along the rod are equal to 1 foot in the vertical, and the rod is graduated accordingly. The channel at the station is fairly straight, above and below. The bed, as elsewhere along this river, is of loose, coarse sand. Two bench marks were established. The first consists of a spike which is driven horizontally in the northeast side of the downstream pile of the bent at the north end of the first truss span on the south end of the bridge. This spike is 7.55 feet above the zero of the gage. The second bench mark is a point on the southeast corner of the window sill at the front of the store. This point is 9.74 feet above the zero of the gage. A measurement of discharge was made at this station by O. V. P. Stout on September 12, 1897. Gage height 2.11 feet; discharge, 551 second feet.

Daily gage height, in feet, of North Platte River at Camp Clarke, Nebraska, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	2.91	2.89	2.80	2.85	4.20	4.55	3.35	2.30	2.20	2.03
2	2.90	2.89	2.76	2.82	4.26	4.50	3.30	2.35	2.19	2.02
3	2.90	2.89	2.72	2.81	4.20	4.51	3.15	2.50	2.10	2.05
4	2.85	2.89	2.74	2.78	4.25	4.68	3.10	2.52	2.20	2.04
5	2.85	2.89	2.78	2.74	4.26	4.90	3.03	2.45	2.18	2.05
6	2.80	2.89	2.78	2.68	4.25	5.00	2.99	2.50	2.14	2.06
7	2.80	2.89	2.85	2.75	4.32	4.78	2.91	2.54	2.13	2.06
8	2.80	2.89	2.79	2.84	4.25	4.50	2.91	.....	2.12	2.08
9	2.80	2.89	2.55	2.80	4.35	4.27	3.05	2.61	2.12	2.08
10	2.80	2.89	2.46	2.65	4.30	4.10	3.05	2.79	2.10	2.06
11	2.80	2.89	2.30	2.75	4.50	3.95	2.97	2.79	2.10	2.12
12	2.84	2.89	2.20	2.80	4.46	3.87	2.96	2.65	2.10	2.10
13	2.84	2.89	2.12	2.60	4.40	4.00	2.90	2.68	2.13	2.10
14	2.84	2.83	.....	2.75	4.35	4.03	2.80	2.67	2.12	2.10
15	2.85	2.80	2.57	2.75	4.17	4.10	2.75	2.60	2.15	2.11
16	2.87	2.75	2.59	2.77	4.07	4.03	2.65	2.54	2.15	2.11
17	2.87	2.65	2.57	2.75	3.94	4.05	2.57	2.50	2.16	2.11
18	2.89	2.75	2.52	2.79	4.05	4.10	2.92	2.49	2.14	2.12
19	2.89	2.86	2.45	2.90	4.07	4.08	2.92	2.43	2.17	2.11
20	2.89	2.90	2.40	3.30	4.25	4.08	2.68	2.35	2.15	2.15
21	2.89	2.85	2.40	3.60	4.33	3.89	2.60	2.29	2.13	2.20
22	2.80	2.85	2.42	3.68	4.26	3.89	2.62	.....	2.10	2.21
23	2.89	2.85	2.45	3.95	4.37	3.65	2.60	2.30	2.09	2.19
24	2.80	2.85	2.43	4.28	4.56	3.62	2.65	2.24	2.10	2.18
25	2.89	2.85	2.45	4.28	7.72	3.47	2.58	2.25	2.09	2.19
26	2.80	2.85	2.42	3.95	4.78	3.50	2.52	2.22	2.10	2.21
27	2.89	2.85	2.43	3.88	4.77	3.49	2.57	2.20	2.11	2.22
28	2.89	2.80	2.41	3.80	4.72	3.51	2.52	2.22	2.10	2.20
29	2.89	.....	2.42	3.88	4.74	3.57	2.56	2.22	2.11	2.21
30	2.89	.....	2.45	4.00	4.70	3.40	2.45	2.18	2.06	2.21
31	2.89	.....	2.80	.....	4.67	.....	2.40	2.20	.....	2.21

NORTH PLATTE STATION ON NORTH PLATTE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 156, is located at the wagon bridge 1 mile north of the town of North Platte, Nebraska. The water, except in times of flood, does not pass under all the spans of the long bridge, but usually the greater part flows under two or three of these, speading out in shallow pools or streamlets under others. The initial point for soundings is on the right bank. The channel is nearly straight for about 500 feet, both above and below the station. The gage is at the railroad bridge 2 miles below the wagon bridge. The zero is 12.00 feet below the top and immediately under the east rail of the track. The observer is Fred Hanlon. The following measurements of discharge were made by C. P. Ross, in 1897:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Apr. 5	2.70	4,038	June 19	3.35	11,393	Sept. 4	1.65	679
Apr. 12	2.80	2,961	June 29	3.05	6,518	Sept. 18	1.70	744
Apr. 26	3.45	10,328	July 10	2.25	4,112	Oct. 6	1.50	486
May 17	3.50	13,486	July 24	2.05	2,940	Oct. 18	1.90	1,343
May 29	4.05	20,796	Aug. 7	2.40	3,118	Nov. 11	1.90	1,511
June 10	3.95	17,172	Aug. 21	2.15	2,306			

Daily gage height, in feet, of North Platte River at North Platte, Nebraska, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.90	2.80	2.50	2.30	3.20	4.10	2.95	1.85	1.75	1.60	2.00	2.30
2	2.85	2.80	2.60	2.55	3.20	4.05	2.80	1.85	1.75	1.50	1.90	2.20
3	3.00	2.80	2.75	2.75	3.25	4.05	2.75	1.85	1.70	1.50	1.80	2.30
4	2.95	2.90	2.85	2.75	3.50	3.90	2.65	1.90	1.65	1.50	1.70	2.30
5	3.00	2.85	2.90	2.85	3.50	3.90	2.55	1.95	1.60	1.50	1.70	2.30
6	3.05	2.85	3.00	2.70	3.45	3.90	2.50	2.45	1.65	1.50	1.80	2.30
7	3.10	2.85	3.05	2.75	3.50	4.10	2.40	2.40	1.55	1.50	1.90	2.30
8	3.15	2.85	3.10	2.85	3.50	4.25	2.35	2.50	1.45	1.50	1.90	2.30
9	3.20	2.95	3.15	2.75	3.65	4.15	2.45	2.40	1.45	1.50	2.00	2.40
10	3.15	3.05	3.25	2.65	3.60	3.90	2.25	2.45	1.50	1.65	2.00	2.45
11	3.15	3.15	3.35	2.65	3.60	3.85	2.10	2.50	1.65	1.55	1.90	2.50
12	3.15	3.15	2.45	2.80	3.65	3.85	2.15	2.35	1.70	1.65	1.90	2.55
13	3.25	3.20	2.50	2.65	3.65	3.55	2.35	2.20	1.60	1.70	1.90	2.70
14	3.25	3.25	2.40	2.55	3.60	3.40	2.10	2.30	1.65	1.65	1.90	2.70
15	3.15	3.25	2.30	2.45	3.65	3.25	2.05	2.45	1.60	1.70	1.90	2.80
16	3.20	3.35	2.25	2.25	3.45	3.35	2.15	2.35	1.65	1.80	1.90	2.80
17	3.20	3.35	2.40	2.25	3.55	3.35	2.15	2.35	1.65	1.85	2.00	2.90
18	3.20	3.35	2.55	2.30	3.45	3.45	2.20	2.35	1.65	1.90	2.00	2.90
19	3.20	3.35	2.25	2.30	3.45	3.35	2.15	2.30	1.60	1.90	2.00	2.90
20	3.20	3.35	2.20	2.35	3.55	3.35	2.35	2.20	1.60	1.80	2.00	2.90
21	3.15	3.35	2.45	2.55	3.50	3.35	2.15	2.15	1.60	1.80	2.00	2.90
22	3.05	3.25	2.40	2.65	3.55	3.35	2.25	2.15	1.60	1.70	1.95	2.90
23	2.90	3.15	2.40	2.85	3.55	3.35	2.40	1.95	1.55	1.70	2.00	2.80
24	2.80	3.05	2.30	3.05	3.60	3.25	2.05	1.90	1.50	1.70	2.00	2.80
25	2.80	2.25	2.05	3.25	3.70	3.25	2.00	1.85	1.55	1.70	1.80	2.70
26	2.90	2.30	2.05	3.45	3.85	3.10	1.95	1.85	1.55	1.85	1.95	2.70
27	2.90	2.30	2.20	3.55	4.00	3.05	1.95	1.80	1.50	1.90	2.15	2.70
28	2.90	2.30	2.10	3.35	4.05	3.10	1.95	1.80	1.50	2.20	2.30	2.60
29	2.90	.....	2.05	3.25	4.05	3.05	1.95	1.75	1.50	2.25	2.30	2.70
30	2.90	.....	2.15	3.20	4.10	3.05	1.90	1.70	1.50	2.20	2.30	2.80
31	2.90	.....	2.20	.....	4.05	.....	1.85	1.70	.....	2.05	.....	2.80

DEANSBURY STATION ON SOUTH PLATTE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 159, is located about 1,000 feet southwest of Deansbury, Colorado. The discharge measurements are made from a footbridge crossing the stream. The gage rod is vertical. An automatic register is also used. Both banks are high and not liable to overflow.

Station No. 2 is located about 300 feet above station No. 1, and is used during the summer months, being a more desirable point for high-water measurements than station No. 1. The gage consists of a 2 by 4 inch inclined timber. The railroad embankment forms the right bank, while the left is low and subject to overflow at high water. The bed of the stream is rocky and not liable to change. The following measurements of discharge were made by L. R. Hope in 1897:

At Station No. 1:

January 8, gage height, 2.75 feet; discharge, 79 second-feet.
January 16, gage height, 2.68 feet; discharge, 85 second-feet.
January 22, gage height, 2.56 feet; discharge, 68 second-feet.
January 31, gage height, 2.33 feet; discharge, 55 second-feet.
February 17, gage height, 2.58 feet; discharge, 71 second-feet.
March 1, gage height, 2.75 feet; discharge, 90 second feet.
March 11, gage height, 2.82 feet; discharge, 103 second-feet.
March 20, gage height, 2.75 feet; discharge, 92 second-feet.
March 27, gage height, 3.40 feet; discharge, 165 second-feet.
April 8, gage height, 4.17 feet; discharge, 260 second-feet.

At Station No. 2:

April 17, gage height, 2.02 feet; discharge, 342 second-feet.
April 22, gage height, 2.62 feet; discharge, 510 second-feet.
May 3, gage height, 3.05 feet; discharge, 643 second-feet.
May 9, gage height, 3.50 feet; discharge, 831 second-feet.
May 23, gage height, 4.15 feet; discharge 1,006 second-feet.
June 10, gage height, 3.85 feet; discharge, 985 second-feet.
July 1, gage height, 3.15 feet; discharge, 678 second-feet.

Daily gage height, in feet, of South Platte River at Deansbury, Colorado, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	Day.	Jan.	Feb.	Mar.	Apr.	May.	June.
1....	2.74	2.38	2.63	3.83	2.92	5.25	17.....	2.70	2.56	2.95	2.16	3.82	4.13
2....	2.76	2.39	2.68	3.80	2.97	4.89	18.....	2.70	2.50	2.99	2.42	3.94	3.97
3....	2.70	2.42	2.67	3.95	3.05	4.66	19.....	2.69	2.55	2.96	2.64	3.92	3.79
4....	2.80	2.41	2.69	4.11	2.97	4.40	20.....	2.67	2.54	2.81	2.81	4.04	3.55
5....	2.80	2.40	2.71	4.23	3.00	4.20	21.....	2.63	2.50	2.90	2.80	4.16	3.60
6....	2.80	2.39	2.74	4.22	3.06	4.26	22.....	2.55	2.72	2.78	2.55	3.95	3.56
7....	2.80	2.41	2.80	4.03	3.26	4.19	23.....	2.55	2.63	2.47	2.45	4.07	3.50
8....	2.80	2.75	2.78	1.65	3.30	3.98	24.....	2.53	2.57	2.65	2.38	4.32	3.38
9 ...	2.62	2.53	2.70	1.66	3.42	3.89	25.....	2.91	2.56	2.91	2.38	4.48	3.32
10....	2.62	2.52	2.58	1.64	3.45	3.85	26.....	3.06	2.55	3.20	2.49	4.43	3.39
11....	2.63	2.63	2.69	1.75	3.61	4.18	27.....	2.41	2.60	3.43	2.77	4.77	3.60
12....	2.63	2.60	2.73	1.77	3.94	4.20	28.....	2.32	2.57	3.64	2.92	4.53	3.58
13....	2.65	2.97	2.70	1.68	3.98	4.23	29.....	2.39	.....	3.84	2.95	4.69	3.55
14....	2.63	3.62	2.62	1.75	3.95	4.23	30.....	2.34	.....	3.99	2.94	4.98	3.50
15....	2.63	2.55	2.82	1.83	3.95	4.37	31.....	2.33	.....	3.72	.....	5.19	.....
16....	2.66	2.50	2.91	1.87	4.08	4.38							

Register move to station No. 2, April 8.

DENVER STATION ON SOUTH PLATTE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 162, is located at the Fifteenth street bridge, Denver, Colorado, immediately below the mouth of Cherry Creek. The inclined gage consists of two 6 by 2 inch planks spiked together and fastened to posts driven into the river bank. Also, a short vertical rod is spiked to a pile near left abutment of the bridge. The bench mark is 107 feet southwesterly from the gage, and is a cross mark on top of the east abutment of the Fifteenth street bridge, on the north corner. It is marked B. M., and is 15.15 feet above the zero of the gage rod. The river is confined between slag embankments, and the bed is sandy and shifting. The observer is J. H. Hodgson. The following discharge measurements were made by F. Cogswell in 1897:

January 15, gage height, 4.70 feet; discharge, 98 second-feet.
April 15, gage height, 5.35 feet; discharge, 385 second-feet.
May 1, gage height, 5.70 feet; discharge, 595 second-feet.
May 25, gage height, 5.85 feet; discharge, 778 second-feet.
June 4, gage height, 6.45 feet; discharge, 1,311 second-feet.
June 15, gage height, 6.75 feet; discharge, 1,406 second-feet.
July 13, gage height, 5.60 feet; discharge, 687 second-feet.
August 5, gage height, 7.45 feet; discharge, 1,849 second-feet.
August 20, gage height, 5.55 feet; discharge, 473 second-feet.
September 6, gage height, 4.95 feet; discharge, 116 second-feet.
October 11, gage height, 5.70 feet; discharge, 413 second-feet.

Daily gage height, in feet, of South Platte River at Denver, Colorado, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.55	4.65	4.60	5.40	5.70	6.65	5.35	4.90	5.20	5.20	6.10	5.45
2	4.60	4.70	4.55	5.45	5.65	6.85	5.05	4.85	5.10	5.30	6.05	5.40
3	4.55	4.70	4.60	5.55	5.65	6.65	5.35	6.10	5.00	5.25	6.00	5.25
4	4.50	4.60	4.65	5.50	5.55	6.45	5.15	7.65	4.85	5.35	6.05	5.10
5	4.55	4.70	4.75	5.60	5.50	6.40	5.30	8.25	4.80	5.35	5.90	5.15
6	4.60	4.65	4.80	5.60	5.40	6.45	5.20	7.40	5.10	5.50	5.95	5.25
7	4.75	4.50	4.75	5.70	5.45	6.40	5.10	7.20	5.05	5.40	5.85	5.35
8	4.80	4.55	4.70	5.55	5.45	6.35	5.05	6.00	5.05	5.45	5.70	5.55
9	4.80	4.45	4.80	5.40	5.40	6.30	5.55	5.80	5.20	5.50	5.65	5.45
10	4.75	4.40	4.85	5.30	5.35	6.35	5.95	5.80	5.05	5.55	5.80	5.35
11	4.75	4.35	4.80	5.25	5.55	6.75	5.80	5.70	4.95	5.80	5.85	5.30
12	4.80	4.25	4.85	5.25	5.75	6.80	6.50	5.70	4.70	5.50	5.75	5.40
13	4.75	4.25	4.90	5.30	5.75	6.70	5.75	5.70	5.05	5.35	5.70	5.45
14	4.65	4.25	4.85	5.25	5.65	6.65	5.60	5.60	5.25	5.25	5.75	5.40
15	4.65	4.35	4.85	5.30	5.70	6.65	5.30	5.70	5.40	5.20	5.70	5.35
16	4.70	4.40	4.95	5.40	5.60	6.55	5.00	5.70	5.30	5.30	5.60	5.20
17	4.80	4.55	5.00	5.50	5.70	6.50	4.80	5.70	5.65	5.40	5.50	5.15
18	4.75	4.60	4.90	5.60	5.75	6.35	4.55	5.70	5.20	5.25	5.65	5.10
19	4.70	4.45	5.00	5.80	5.65	6.25	5.55	5.60	5.50	5.30	5.75	5.10
20	4.65	4.40	4.95	5.90	5.80	6.10	5.70	5.55	5.45	5.25	5.80	5.15
21	4.60	4.50	5.00	6.00	6.05	6.00	5.70	5.45	5.40	5.25	5.70	5.20
22	4.65	4.55	5.05	5.60	5.85	5.95	5.55	5.35	5.30	5.25	5.70	5.25
23	4.60	4.65	5.05	5.35	5.80	5.85	5.35	5.38	5.25	5.20	5.60	5.35
24	4.55	4.70	5.10	5.30	5.75	5.75	5.25	5.30	5.30	5.30	5.60	5.35
25	4.50	4.65	5.15	5.20	6.10	5.65	5.30	5.25	5.25	5.35	5.50	5.40
26	4.55	4.75	5.20	5.15	6.05	5.60	5.15	5.20	5.00	5.40	5.30	5.40
27	4.50	4.70	5.25	5.10	6.80	5.75	5.05	5.05	5.30	5.50	5.00	5.35
28	4.55	4.55	5.30	5.25	6.65	5.65	5.10	5.10	5.00	5.75	4.80	5.40
29	4.65	.....	5.35	5.50	6.55	5.65	5.15	5.35	4.85	5.90	4.95	5.55
30	4.70	.....	5.40	5.65	6.70	5.55	5.00	5.35	4.85	5.80	5.25	5.45
31	4.60	.....	5.35	.....	6.60	.....	4.90	5.20	.....	5.95	.....	5.40

ORCHARD STATION ON SOUTH PLATTE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 166, is located one-fourth mile southwest of Orchard, Colorado. The gage is inclined, consisting of two 2 by 4 inch planks, spiked together and fastened to posts driven into the river bank. It is marked to vertical 0.10 of a foot, the space between the marks being 0.127 of a foot. The bench mark consists of a 2 by 4 inch stick driven almost to the surface of the ground 8 feet back from the rod. The top of this is 8.30 feet above the zero of the gage rod. The initial point for soundings is on the right shore. The left bank is high and the right low and liable to overflow, the bed of the stream being sandy and shifting. Measurements are made by wading. The primary object of this station is to obtain the winter flow of the Platte at this point. The observer is Mrs. U. E. Foley. The following discharge measurements were made by F. Cogswell and others in 1897:

January 18, gage height, 4.14 feet; discharge, 377 second-feet.
May 28, gage height, 5.00 feet; discharge, 1,921 second-feet.
June 20, gage height, 4.60 feet; discharge, 1,926 second-feet.
June 27, gage height, 3.20 feet; discharge, 504 second-feet.
July 25, gage height, 3.60 feet; discharge, 524 second-feet.
September 13, gage height, 2.50 feet; discharge, 86 second-feet.
November 9, gage height, 4.40 feet; discharge, 1,299 second-feet.

Daily gage height, in feet, of South Platte River at Orchard, Colorado, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.75	4.50	3.80	4.20	3.75	5.80	3.20	3.00	2.75	2.50	4.45	3.90
2	3.80	4.50	3.80	4.30	3.65	6.20	3.10	3.00	2.60	2.50	4.50	5.00
3	3.80	4.50	3.80	4.30	3.40	6.50	3.00	3.00	2.50	2.50	4.50	5.05
4	3.80	4.50	3.80	4.30	3.40	6.30	2.90	3.00	2.50	2.50	4.50	4.70
5	3.85	4.55	3.80	4.30	3.40	6.20	2.35	4.40	2.50	2.50	4.50	4.70
6	3.90	4.55	3.80	4.30	3.35	5.95	2.35	5.30	2.50	2.50	4.50	4.70
7	3.95	4.50	3.80	4.30	3.30	5.40	2.35	5.30	2.50	2.50	4.50	4.75
8	4.25	4.45	3.75	4.35	3.20	4.75	2.30	5.30	2.50	2.50	4.50	4.80
9	4.35	4.40	3.75	4.35	3.00	4.50	2.30	5.40	2.45	2.50	4.40	5.00
10	4.30	4.30	3.75	4.35	3.00	4.50	2.30	5.20	2.45	2.50	4.30	4.90
11	4.35	4.20	3.70	4.40	2.90	5.50	4.00	5.10	2.40	2.50	4.30	4.70
12	4.35	4.10	3.70	4.40	2.80	6.30	3.70	4.50	2.50	2.55	4.20	4.20
13	4.30	4.00	3.70	4.35	2.80	6.50	3.25	4.30	2.50	2.80	4.30	3.90
14	4.30	6.00	4.60	4.30	2.75	6.80	2.50	4.15	2.60	2.80	4.30	4.20
15	4.30	7.00	3.80	4.25	2.70	6.70	2.50	4.00	2.60	2.85	4.20	4.00
16	4.30	6.00	3.70	4.20	2.60	6.40	2.40	4.00	2.60	2.85	4.15	3.60
17	4.30	4.00	3.70	4.20	2.55	6.20	2.35	3.80	2.60	2.90	4.10	3.60
18	4.15	3.90	3.70	4.20	2.50	5.95	2.35	3.70	2.60	3.00	4.10	3.55
19	4.25	3.90	3.70	4.15	2.50	4.75	2.70	3.65	2.60	3.10	4.10	3.70
20	4.35	3.90	3.70	4.15	2.70	4.60	2.95	3.40	2.60	3.20	4.00	3.90
21	4.45	3.85	3.70	4.15	3.20	4.50	3.60	3.35	2.50	3.30	4.00	4.10
22	4.50	3.85	3.70	4.10	4.50	4.40	3.60	3.30	2.45	3.30	4.05	4.10
23	4.55	3.80	3.75	4.10	4.70	4.30	3.90	3.20	2.50	3.35	4.10	4.10
24	4.50	3.80	3.75	4.05	5.00	4.10	3.60	3.00	2.50	3.40	4.00	4.20
25	4.30	3.75	3.80	4.00	5.10	3.95	3.60	2.90	2.50	3.40	4.00	4.30
26	4.25	3.75	3.80	4.00	5.20	3.80	3.60	2.85	2.50	3.45	4.00	4.30
27	4.20	3.75	3.80	3.95	5.30	3.50	3.60	2.85	2.50	3.65	4.00	4.35
28	4.20	3.75	3.80	3.95	5.80	3.30	3.50	2.75	2.50	3.85	4.00	4.40
29	4.35	.....	3.80	3.90	5.80	3.25	3.45	2.75	2.50	4.00	3.90	4.50
30	4.45	.....	3.80	3.85	5.98	3.25	3.30	2.75	2.50	4.20	3.80	4.55
31	4.50	.....	3.90	.....	5.85	.....	3.20	2.75	.....	4.40	.....	4.60

MORRISON STATION ON BEAR CREEK.

This station, described in the Eighteenth Annual Report, Part IV, page 167, is located in the upper part of the town of Morrison, Colorado. The gage rod is placed in the river about 150 feet above the railroad depot. It consists of two inclined planks, 2 by 4 inches by 8 feet long, spiked together and fastened to posts driven into the ground. It is divided into vertical tenths of a foot, the space between the marks being 0.127 of a foot. Three nails in a tree in right bank 190.5 feet below gage rod are 10.14 feet above zero of gage. Both banks are low and liable to overflow at high water. Measurements are made by wading, but the bridge above the gage can be used at high water. The observer is Henry Hines. The following measurements of discharge were made by R. S. Sumner and others in 1897:

May 20, gage height, 3.60 feet; discharge, 179 second-feet.
June 13, gage height, 3.70 feet; discharge, 209 second-feet.
June 26, gage height, 3.50 feet; discharge, 162 second-feet.
July 24, gage height, 3.45 feet; discharge, 131 second-feet.
September 11, gage height, 3.05 feet; discharge, 55 second-feet.
October 12, gage height, 3.00 feet; discharge, 52 second-feet.

Daily gage height, in feet, of Bear Creek at Morrison, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	3.85	3.35	3.20	3.20	3.05	3.00
2	.....	3.65	3.30	3.60	3.15	3.05	3.00
3	3.35	3.55	3.25	4.15	3.15	3.05	2.90
4	3.35	3.60	3.20	5.05	3.15	3.05	2.90
5	3.35	3.60	3.20	4.75	3.15	3.05	2.90
6	3.45	3.65	3.20	4.10	3.05	3.05	2.90
7	3.40	3.55	3.15	4.15	3.05	3.05	2.85
8	3.35	3.55	3.35	3.90	3.05	3.05	2.85
9	3.30	3.55	3.95	3.80	3.05	3.15	2.90
10	3.35	3.55	3.80	3.75	3.05	3.05	3.00
11	3.25	3.80	3.45	3.65	3.05	3.05	3.00
12	3.25	3.85	3.40	3.65	3.05	3.00	3.00
13	3.35	3.75	3.30	3.50	3.05	3.00	3.00
14	3.45	4.00	3.25	3.45	3.15	3.00	3.00
15	3.45	3.70	3.25	3.55	3.35	3.00	3.00
16	3.55	3.65	3.25	3.55	3.25	3.00	3.00
17	3.35	3.55	3.25	3.55	3.15	3.00	2.90
18	3.45	3.55	3.30	3.45	3.15	3.00	2.90
19	3.45	3.55	3.50	3.45	3.15	3.00	2.90
20	3.55	3.55	3.45	3.45	3.15	3.00	2.90
21	3.55	3.50	3.35	3.35	3.15	3.00	2.90
22	3.45	3.45	3.35	3.35	3.10	3.00	2.90
23	3.45	3.45	3.45	3.30	3.05	3.00	2.85
24	3.65	3.45	3.45	3.25	3.05	3.00	2.45
25	3.75	3.40	3.35	3.25	3.05	3.00	2.50
26	3.55	3.45	3.35	3.25	3.05	3.00	2.50
27	3.80	3.50	3.25	3.25	3.05	3.00	2.50
28	3.65	3.45	3.25	3.25	3.05	3.15	2.55
29	3.75	3.45	3.20	3.25	3.00	3.15	2.70
30	3.80	3.40	3.20	3.25	3.05	3.10	2.70
31	3.80	.....	3.20	3.25	.....	3.10	.....

MARSHALL STATION ON SOUTH BOULDER CREEK.

This station, described in the Eighteenth Annual Report, Part IV, page 169, is located about 3 miles west of Marshall, Colorado. The gage consists of an inclined 2 by 6 inch timber, with a 1 by 6 inch scale nailed to it, and is fastened to a tree and to stakes driven into the ground. It is marked to vertical 0.10 of a foot, the distance between the marks being 0.22 of a foot. The bench mark is a stone, 15 feet northwest of the gage, marked with black paint. Its elevation is 6.99 feet above zero of rod. Measurements are usually made by wading near the gage, but a footbridge 20 feet above can be used in high water. The Community Ditch and the South Boulder and Coal Creek Ditch both take out water above the gage, and this amount must be added to the discharge at the station to obtain total run-off of the drainage basin of the creek. The observer is C. E. Barber. The following measurements of discharge were made by F. Cogswell and others in 1897:

May 22, gage height, 2.45 feet; discharge, 348 second-feet.
June 19, gage height, 2.60 feet; discharge, 363 second-feet.
June 25, gage height, 2.50 feet; discharge, 370 second-feet.
July 27, gage height, 1.65 feet; discharge, 122 second-feet.
August 13, gage height, 1.55 feet; discharge, 116 second-feet.
October 14, gage height, 0.82 foot; discharge, 14 second-feet.

Daily gage height, in feet, of South Boulder Creek at Marshall, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	3.25	2.40	1.65	1.25	1.15	1.20
2	1.60	3.10	2.40	1.65	1.25	1.15	1.00
3	1.70	2.75	2.40	1.75	1.20	1.10	1.00
4	1.65	2.55	2.25	2.25	1.15	1.05	1.10
5	1.90	2.55	2.10	2.25	1.10	1.10	.90
6	1.95	2.35	2.20	2.20	1.00	1.20	.90
7	1.85	2.30	2.10	2.25	.90	1.25	.85
8	2.00	2.30	2.10	1.85	1.10	1.25	.85
9	2.00	2.30	2.80	1.80	1.10	1.30	.95
10	1.90	2.50	2.60	1.65	1.15	1.10	.90
11	1.85	3.40	2.35	1.65	1.10	1.10	1.00
12	1.75	3.10	2.25	1.60	1.15	.95	1.15
13	1.75	3.10	2.15	1.60	1.15	.90	1.15
14	1.90	2.90	2.15	1.65	1.20	.85	1.20
15	2.05	2.85	2.10	1.60	1.20	.85	1.15
16	2.10	2.95	2.00	1.55	1.25	1.25	1.15
17	2.15	2.85	2.00	1.55	1.30	1.05	1.15
18	2.20	2.50	2.05	1.55	1.20	1.00	1.05
19	2.30	2.60	2.05	1.45	1.10	1.00	1.05
20	2.50	2.60	1.85	1.35	1.15	.90	1.05
21	2.50	2.60	1.85	1.35	1.15	.95	1.05
22	2.55	2.60	1.75	1.35	1.10	.95	1.15
23	2.65	2.60	1.80	1.35	1.05	.90	1.05
24	2.95	2.45	1.75	1.40	1.05	.90	1.10
25	3.00	2.55	1.75	1.40	1.00	1.05	1.05
26	2.85	2.80	1.70	1.30	1.00	1.25	1.00
27	3.25	2.65	1.70	1.35	1.00	1.00	1.10
28	3.05	2.45	1.65	1.40	1.05	1.20	.95
29	3.15	2.35	1.60	1.40	1.10	1.25	.95
30	3.15	2.30	1.60	1.35	1.05	1.10	.85
31	3.05	.....	1.65	1.30	.....	1.15	.....

BOULDER STATION ON BOULDER CREEK.

This station, described in the Eighteenth Annual Report, Part IV, page 171, is located about 1½ miles above the town of Boulder, Colorado. The gage rod consists of an inclined 2 by 6 inch timber, with a 1 by 6 inch scale fastened to it, and spiked to stakes driven into the ground. It is marked to vertical 0.10 of a foot, the space between the marks being 0.207 of a foot. The bench mark is a large stone, 20 feet north of the gage. Its elevation is 9.95 feet above the zero of the rod. The observer is Mrs. Carrie Osgood. Both banks are high and rocky, and not liable to overflow. The bed of the creek is quite rocky. Measurements are usually made by wading, but during high water can be made from a bridge 40 feet above the gage. On June 14, 1897, this bridge was carried out by a flood. The following measurements of discharge were made by F. Cogswell and others in 1897:

May 21, gage height, 2.15 feet; discharge, 377 second-feet.
July 26, gage height, 1.75 feet; discharge, 288 second-feet.
August 12, gage height, 1.55 feet; discharge, 224 second-feet.
October 13, gage height, 0.55 foot; discharge, 48 second-feet.

Daily gage height, in feet, of Boulder Creek at Boulder, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	1.35	2.68	2.12	1.62	1.00	0.62	0.40
2	1.40	2.50	2.15	1.75	.95	.65	.43
3	1.42	2.28	2.20	2.00	.95	.60	.55
4	1.45	2.12	2.48	2.20	.90	.60	.53
5	1.50	2.02	1.90	2.15	.85	.55	.50
6	1.50	2.00	1.85	1.92	.80	.58	.45
7	1.55	1.90	1.85	1.78	.80	.70	.48
8	1.65	1.90	2.20	1.80	.75	.95	.52
9	1.60	2.10	2.85	1.70	.75	.78	.55
10	1.60	3.02	2.55	1.68	.78	.72	.50
11	1.55	3.05	2.38	1.58	.88	.70	.45
12	1.45	2.72	2.15	1.58	1.05	.65	.40
13	1.50	2.75	2.08	1.52	1.08	.58	.45
14	1.58	2.70	2.08	1.45	1.28	.55	.50
15	1.80	2.80	2.00	1.40	1.18	.60	.38
16	1.85	2.75	1.98	1.40	1.12	.68	.25
17	1.85	2.58	1.90	1.38	1.08	.70	.38
18	1.90	2.35	1.92	1.35	1.00	.68	.48
19	2.12	2.32	2.00	1.35	.92	.58	.55
20	2.20	2.40	1.90	1.32	.90	.55	.52
21	2.18	2.45	1.80	1.30	.85	.60	.55
22	2.18	2.50	1.65	1.25	.82	.55	.50
23	2.30	2.48	1.70	1.22	.70	.53	.52
24	2.42	2.42	1.82	1.18	.68	.48	.55
25	2.50	2.42	1.88	1.12	.65	.50	.45
26	2.48	2.50	1.75	1.08	.65	.42	.30
27	2.62	2.40	1.70	1.05	.60	.38	.28
28	2.45	2.35	1.62	1.37	.60	.42	.45
29	2.45	2.28	1.60	1.12	.60	.50	.75
30	2.42	2.25	1.55	1.02	.65	.45	.97
31	2.48	.....	1.60	1.05	.....	.48	.....

LYONS STATION ON ST. VRAIN CREEK.

This station, described in the Eighteenth Annual Report, Part IV, page 172, is located one-half mile southeast of Lyons, Colorado, below the intersection of the north and south forks of St. Vrain Creek. The Supply ditch takes water out on the left side of the stream, above the gage. To obtain the total run-off of the drainage basin of the creek at this station, the amount of water in the ditch will have to be added to the discharge of the creek. The gage is an inclined 2 by 4 inch timber, marked to vertical 0.10 of a foot, the space between the marks being 0.134 of a foot, and is fastened to posts driven into the ground. Both banks are low and liable to overflow, and the bed of the stream is composed of gravel. Measurements are usually made by wading, but at high water can be made from a wagon bridge 400 feet below the gage. The observer is Miss Bessie Sites. The following measurements of discharge were made by F. Cogswell and others in 1897:

May 25, gage height, 4.15 feet; discharge, 659 second-feet.
June 17, gage height, 4.40 feet; discharge, 713 second-feet.
June 28, gage height, 3.70 feet; discharge, 551 second-feet.
July 20, gage height, 3.10 feet; discharge, 379 second-feet.
September 15, gage height, 2.10 feet; discharge, 115 second-feet.
November 10, gage height, 1.75 feet; discharge, 54 second-feet.

Daily gage height, in feet, of St. Vrain Creek at Lyons, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	4.95	3.65	2.85	2.15	1.85	1.65
2	3.08	4.55	3.55	2.85	2.15	1.85	1.65
3	3.05	4.05	3.75	3.00	2.05	1.85	1.60
4	2.95	3.60	3.35	3.10	2.05	1.85	1.60
5	3.00	3.50	3.25	3.75	2.05	1.75	1.60
6	3.05	3.45	3.35	3.10	2.05	1.75	1.55
7	3.05	3.35	3.45	2.95	2.05	1.75	1.55
8	3.20	3.55	3.50	2.85	2.00	1.75	1.55
9	3.15	4.15	4.95	2.75	2.00	1.75	1.60
10	3.15	4.35	4.55	2.75	2.05	1.75	1.60
11	3.10	5.45	3.80	2.70	2.05	1.75	1.60
12	3.00	5.25	3.50	2.75	1.95	1.75	1.55
13	3.05	5.10	3.50	2.65	2.25	1.65	1.55
14	3.10	5.00	3.45	2.65	2.30	1.65	1.55
15	3.25	5.10	3.70	2.55	2.25	1.65	1.55
16	3.35	5.10	3.35	2.55	2.35	1.65	1.55
17	3.35	4.35	3.40	2.55	2.25	1.80	1.65
18	4.65	4.00	3.35	2.55	2.25	1.70	1.65
19	3.70	3.80	3.55	2.55	2.15	1.65	1.65
20	3.60	4.00	3.45	2.65	2.05	1.65	1.65
21	3.70	4.20	3.25	2.55	2.05	1.65	1.65
22	3.55	4.10	3.20	2.55	2.05	1.65	1.65
23	3.90	4.25	2.85	2.55	2.05	1.65	1.65
24	4.10	4.00	3.20	2.65	1.95	1.65	1.65
25	4.30	4.00	3.05	2.55	1.95	1.55	1.65
26	4.25	4.30	2.95	2.35	1.95	1.55	1.75
27	4.80	3.85	2.95	2.35	1.95	1.55	1.75
28	4.45	3.85	2.75	2.35	1.85	1.65	1.65
29	4.25	3.75	2.85	2.35	1.85	1.65	1.55
30	4.40	3.65	2.75	2.25	1.85	1.65	1.55
31	4.40	.....	2.85	2.15	.....	1.65	.....

ARKINS STATION ON BIG THOMPSON RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 174, is located about 9 miles west of Loveland, Colorado, and about 600 feet below the Home Supply Dam. The gage is vertical, unpainted, but notched for each foot and 0.10 of a foot, and is fastened to the timbers of a bridge. The bench mark is a notch in a tree about 50 feet below the gage, on the left-hand side of the stream. Its elevation is 4.92 feet above the zero of the rod. The right bank is high, but the left is low, and liable to overflow at high water. The bed of the stream is of gravel, with some bowlders. Measurements are usually made from the upper side of the wagon bridge. The head gates of the Home Supply Ditch and Handy Ditch are located above the dam. The observer is E. Chasteen. The following measurements of discharge were made by R. S. Sumner and others in 1897:

May 26, gage height, 2.45 feet; discharge, 804 second-feet.
June 18, gage height, 1.60 feet; discharge, 400 second-feet.
June 29, gage height, 1.50 feet; discharge, 409 second-feet.
July 21, gage height, 1.20 feet; discharge, 214 second-feet.
September 16, gage height, 0.60 foot; discharge, 61 second-feet.
November 11, gage height, 0.65 foot; discharge, 79 second-feet.

Daily gage height, in feet, of Big Thompson River at Arkins, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	0.60	2.40	1.30	1.20	0.40	0.40	0.10
2	.85	1.85	1.30	1.15	.40	.40	.10
3	.65	1.55	1.30	1.15	.40	.30	.20
4	1.00	1.35	1.15	1.30	.45	.30	.50
5	.95	1.25	.95	1.55	.30	.30	.45
6	1.25	.45	.95	1.25	.30	.25	.50
7	1.40	.40	1.10	1.15	.30	.15	.50
8	1.45	1.30	1.30	1.10	.30	.20	.45
9	1.45	1.75	1.70	1.10	.35	.35	.50
10	1.40	1.90	1.65	1.10	.40	.30	.35
11	1.40	2.55	1.40	1.05	.40	.30	.60
12	1.35	2.40	1.30	1.00	.55	.20	.00
13	1.35	2.35	1.20	.90	.65	.10	.00
14	1 50	2.10	1.40	1.00	.70	.10	.00
15	1.70	2.25	1.65	.85	.65	.08	.00
16	1.75	2.20	1.45	.70	.55	.03	.00
17	1.60	1.75	1.35	.80	.60	.08	.00
18	1.70	1.50	1.45	.65	.45	.10	.00
19	1.75	1.70	1.50	.60	.35	.00	.15
20	1.95	1.55	1.40	.70	.30	.00	.30
21	2.05	1.75	1.10	.60	.20	.00	.30
22	1.85	1.65	1.15	.60	.15	.00	.25
23	2.10	1.65	1.15	.60	.35	·00	.25
24	2.05	1.55	1.40	.55	.30	.00	.35
25	2.15	1.65	1.25	.45	.30	.00	.25
26	2.05	1.80	1.15	.40	.25	.00	.25
27	2.10	1.70	1.15	.50	.20	.00	.45
28	1.85	1.40	1.00	.50	.20	.00	.45
29	1.90	1.40	1.00	.55	.20	.25	.45
30	1.90	1.35	1.00	.60	.35	.50	.45
31	2.15	.....	1.10	.55	.....	.20	.....

ST. PAUL STATION ON NORTH LOUP RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 176, is located on the left bank, at the lower side of the wagon bridge, 4 miles north of St. Paul, Nebraska. The gage consists of a piece of oak, 2 by 3 inches, 16 feet long, with the face inclined 30 degrees to the horizontal. This rests upon cross-ties well bedded and covered, the bottom of the rod being thrust into the bed of the river. The zero of this rod is 15.01 feet below the top of the lower horizontal projecting part of the footplate at the north end of the west truss of the north span of the bridge. Bench mark 2 is the standard iron pipe with brass cap of the United States Geological Survey. It is set with the top 5 inches above the ground and 169 feet north of the gage rod. Its elevation is 6.54 feet above zero of gage. The observer is James Stout, jr. The bed of the river is sandy and is liable to change during floods. The following measurements of discharge were made by Adna Dobson and O. V. P. Stout in 1897:

April 20, gage height, 2.89 feet; discharge, 1,281 second-feet.
May 11, gage height, 2.85 feet; discharge, 1,080 second-feet.
May 28, gage height, 2.76 feet; discharge, 1,061 second-feet.
June 19, gage height, 2.94 feet; discharge, 933 second-feet.
July 17, gage height, 2.66 feet; discharge, 615 second-feet.
July 28, gage height, 2.85 feet; discharge, 708 second-feet.
August 18, gage height, 2.82 feet; discharge, 659 second-feet.
October 10, gage height, 2.92 feet; discharge, 819 second-feet.
October 31, gage height, 3.17 feet; discharge, 1,525 second-feet.

Daily gage height, in feet, of North Loup River at St. Paul, Nebraska, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	.....	.....	2.86	2.95	2.65	3.80	2.78	2.75	2.91
2	3.85	3.70	3.70	3.04	2.93	2.70	3.48	2.75	2.75	2.90
3	.....	.....	.....	3.82	2.90	2.76	4.02	2.75	2.85	2.92
4	.....	3.72	3.78	3.90	2.94	2.84	3.12	2.75	2.79	2.85
5	3.80	.....	.....	2.80	2.92	2.82	3.13	2.81	2.80	2.85
6	.....	3.72	3.79	2.78	2.93	2.81	2.97	2.76	2.83	2.88
7	.....	.....	.....	2.70	2.95	2.79	2.95	3.12	2.84	2.88
8	4.00	3.75	.....	2.63	2.90	2.83	2.97	2.98	2.85	2.87
9	.....	.....	3.80	2.68	2.92	2.80	2.74	2.95	2.73	2.91
10	4.40	3.85	3.86	2.64	2.87	2.78	2.81	2.96	3.35	2.91
11	.....	.....	4.08	3.11	2.87	2.78	2.83	2.87	3.00	2.90
12	.....	3.88	4.22	3.12	2.85	2.77	2.81	2.84	2.97	2.88
13	4.70	.....	a2.84	3.10	2.82	2.78	2.87	2.82	2.95	2.93
14	.....	3.90	2.82	3.07	2.88	2.90	2.83	2.85	2.92	2.95
15	4.50	.....	2.80	3.05	2.85	2.95	2.75	2.82	2.89	2.97
16	.....	3.92	2.83	2.96	2.85	2.95	2.67	2.82	2.89	3.04
17	.....	.....	.....	2.95	2.81	2.90	2.80	2.90	2.85	3.32
18	4.20	3.93	2.80	2.95	2.79	3.00	2.76	2.91	2.84	3.25
19	.....	.....	.....	3.04	2.76	2.94	2.89	2.85	2.84	3.01
20	.....	3.95	2.86	2.88	2.77	2.90	2.79	2.82	2.86	3.12
21	.....	.....	.....	2.93	2.76	3.70	2.77	2.83	2.86	3.05
22	.....	4.00	2.85	2.98	2.75	3.50	2.75	2.80	2.83	3.02
23	.....	.....	2.85	3.02	2.77	3.30	2.78	2.85	2.85	3.02
24	.....	3.62	.....	2.87	2.76	3.10	2.80	2.79	2.85	3.00
25	.....	.....	2.90	2.85	2.75	2.98	2.83	2.77	2.84	3.08
26	3.78	3.62	.....	2.77	2.75	2.71	2.80	2.75	2.87	3.05
27	.....	.....	3.12	2.79	2.75	.....	2.94	2.73	2.82	3.03
28	3.82	3.62	.....	2.83	2.70	3.89	2.81	2.75	2.83	3.00
29	.....	.....	.....	2.89	2.68	3.30	2.79	2.80	2.82	3.02
30	3.80	.....	.....	2.90	2.68	4.64	2.75	2.77	2.85	3.01
31	.....	.....	.....	.....	2.67	.....	2.74	2.73	.....	.....

a Ice going out.

ST. PAUL STATION ON MIDDLE LOUP RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 179, is located on the right bank of the stream, at the lower side of the wagon and railroad bridge, 1 mile south of St. Paul, Nebraska. The gage consists of an oak stick, 2 by 3 inches, 16 feet long, inclined 30 degrees to the horizon. This is securely fastened to cross-ties bedded in the soil. The zero of the rod is 9.62 feet below the bottom of the downstream end of the cap of the first river bent at the south end of the bridge. Bench mark 2 is the regulation 4-foot iron post of the United States Geological Survey, and is placed with its top 3 inches above the ground, 50 feet southeast of the gage, and 100 feet at right angles from line of downstream rail of bridge. Its elevation is 7.35 feet above the zero of the gage. The observer is A. C. Snyder, a farmer, who lives one-third mile distant. The following measurements of discharge were made by Adna Dobson and O. V. P. Stout in 1897:

April 21, gage height, 1.74 feet; discharge, 1,792 second-feet.
May 11, gage height, 1.77 feet; discharge, 1,441 second-feet.
May 27, gage height, 1.84 feet; discharge, 1,256 second-feet.
June 18, gage height, 1.87 feet; discharge, 979 second-feet.
July 16, gage height, 1.58 feet; discharge, 816 second-feet.
July 27, gage height, 1.56 feet; discharge, 666 second-feet.
August 18, gage height, 1.65 feet; discharge, 661 second-feet.
October 9, gage height, 1.70 feet; discharge, 814 second-feet.
October 30, gage height, 1.68 feet; discharge, 1,671 second-feet.

Daily gage height, in feet, of Middle Loup River at St. Paul, Nebraska, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	1.50	2.40	.....	1.78	1.43	1.66	2.64	1.42	1.67	1.60
2	1.20	.....	2.26	1.95	1.50	1.69	2.60	1.48	1.60	1.58
3	.....	.....	3.59	2.40	1.54	1.94	2.17	1.50	1.55	1.65
4	.....	2.35	3.20	2.35	1.60	1.86	1.85	1.49	1.48	1.72
5	.....	.....	.....	1.80	1.65	1.86	1.75	1.67	1.50	1.76
6	2.00	.....	.....	1.95	1.68	1.67	1.68	1.75	1.62	1.68
7	2.20	.....	3.61	1.89	1.65	1.76	1.65	1.71	1.44	1.65
8	2.45	2.31	.....	1.78	1.70	1.75	1.58	1.95	1.38	1.67
9	2.57	.....	.....	1.63	1.78	1.74	1.55	1.92	1.43	1.64
10	.....	.....	3.00	1.66	1.75	1.79	1.69	2.25	1.74	1.78
11	2.89	.....	2.26	1.80	1.77	1.90	1.70	1.78	1.70	1.82
12	.....	2.33	1.45	2.25	1.72	1.85	1.78	1.85	1.73	1.80
13	2.88	.....	.....	2.03	1.78	1.77	1.72	1.77	1.76	1.68
14	2.87	.....	.....	2.25	1.76	1.80	1.55	1.75	1.71	1.80
15	2.70	.....	1.50	2.05	1.63	1.86	1.50	1.73	1.74	1.72
16	.....	2.30	.....	1.90	1.65	1.84	1.47	1.68	1.72	1.83
17	.....	.....	2.10	1.90	1.67	1.89	1.53	1.64	1.65	1.90
18	.....	2.38	2.10	1.65	1.77	1.87	1.60	1.60	1.63	1.90
19	2.47	.....	1.85	1.60	1.73	1.83	1.61	1.66	1.68	1.88
20	.....	2.74	1.86	1.63	1.68	1.68	1.72	1.63	1.65	1.80
21	.....	.....	.....	1.75	1.86	1.70	1.67	1.65	1.67	1.73
22	.....	.....	1.91	1.70	1.68	1.75	1.64	1.64	1.69	1.75
23	.....	.....	1.90	1.58	1.80	1.77	1.71	1.67	1.70	1.78
24	.....	2.15	.....	1.77	1.73	1.68	1.68	1.65	1.68	1.76
25	.....	.....	1.70	1.86	1.77	1.70	1.68	1.51	1.65	1.73
26	2.40	2.00	1.70	1.78	1.73	1.87	1.70	1.48	1.71	2.20
27	.....	.....	.....	1.80	1.83	1.92	1.58	1.50	1.64	2.55
28	.....	.....	.....	1.75	1.78	1.79	1.55	1.56	1.68	1.98
29	.....	.....	.....	1.88	1.75	1.77	1.67	1.64	1.50	1.89
30	.....	.....	.....	1.60	1.67	3.11	1.65	1.72	1.56	1.50
31	.....	.....	1.69	.....	1.68	.....	1.58	1.75	.....	1.77

COLUMBUS STATION ON LOUP RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 182, is located near the iron bridge of the Union Pacific Railway, just west of Columbus, Nebraska. The observer is M. Savage, bridge watchman. The gage is 50 yards from the bridge, and is of oak, 3 by 6 inches, 12 feet long, fastened by lag screws to a pile, which forms part of the training works above the bridge. The rod is vertical. The 12-foot mark on the rod is 7 feet below a point 2 feet east of the third panel point of the north truss of the east span, counting the end of the span as the first panel point. Bench mark 2 is the regulation 4-foot iron post of the United States Geological Survey, placed 72 feet east of gage rod. Its elevation is 13.27 feet above zero of gage. The following discharge measurements were made by Adna Dobson and O. V. P. Stout in 1897:

March 19, gage height, 5.22 feet; discharge, 6,307 second-feet.
March 23, gage height, 4.85 feet; discharge, 3,869 second-feet.
April 27, gage height, 4.53 feet; discharge, 2,972 second-feet.
April 27, gage height, 4.53 feet; discharge, 3,103 second-feet.
May 25, gage height, 4.77 feet; discharge, 2,572 second-feet.
May 25, gage height, 4.77 feet; discharge, 2,410 second-feet.
June 17, gage height, 4.72 feet; discharge, 2,818 second-feet.
July 16, gage height, 4.01 feet; discharge, 2,513 second-feet.
July 29, gage height, 3.87 feet; discharge, 1,660 second-feet.
August 17, gage height, 4.27 feet; discharge, 1,783 second-feet.
August 29, gage height, 4.21 feet; discharge, 1,436 second-feet.
October 7, gage height, 4.19 feet; discharge, 1,926 second-feet.
October 30, gage height, 4.70 feet; discharge, 4,580 second-feet.
November 21, gage height, 4.40 feet; discharge, 3,006 second-feet.

Daily gage height, in feet, of Loup River at Columbus, Nebraska, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	5.24	.....	.....	.....	4.46	4.52	7.71	3.89	4.24	4.16
2	.....	.....	7.53	.....	4.44	4.44	5.32	3.85	4.20	4.16
3	.....	.....	.....	5.83	4.52	4.41	4.69	3.81	4.15	4.17
4	.....	.....	.....	.....	4.54	4.80	4.60	3.79	4.15	4.16
5	4.96	.....	7.59	.....	4.56	4.64	4.48	4.02	4.13	4.16
6	.....	.....	.....	.....	4.57	4.78	4.22	4.42	4.09	4.16
7	.....	.....	.....	.....	4.57	4.70	4.02	4.31	4.12	4.17
8	5.18	.....	.....	4.88	4.60	4.68	3.84	4.39	4.03	4.18
9	.....	.....	7.68	4.77	4.62	4.68	3.78	4.71	4.07	4.16
10	.....	.....	.....	4.70	4.69	4.68	3.86	4.70	4.22	4.18
11	.....	.....	.....	4.56	4.63	4.68	3.92	4.81	4.31	4.29
12	7.18	.....	8.45	4.44	4.66	4.70	4.02	4.61	4.36	4.43
13	.....	.....	.....	4.84	4.63	4.77	3.96	4.54	4.36	4.46
14	.....	.....	.....	4.93	4.63	4.75	3.91	4.48	4.34	4.44
15	7.04	.....	.....	4.74	4.66	4.76	4.20	4.40	4.34	4.44
16	.....	.....	5.73	4.70	4.67	4.74	4.08	4.33	4.30	4.50
17	.....	.....	.....	4.77	4.66	4.72	3.92	4.28	4.37	4.58
18	.....	.....	.....	4.91	4.65	4.69	3.84	4.19	4.28	5.00
19	.....	.....	5.43	4.53	4.66	4.82	3.78	4.17	4.25	5.02
20	.....	6.45	.....	4.63	4.62	4.74	3.95	4.15	4.23	4.86
21	.....	.....	.....	4.61	4.64	4.54	4.00	4.15	4.20	4.82
22	.....	.....	.....	4.62	4.77	4.43	3.96	4.15	4.20	4.76
23	.....	6.45	4.85	4.86	4.78	4.35	3.95	4.15	4.21	4.72
24	.....	.....	.....	4.82	4.82	4.34	3.96	4.16	4.24	4.80
25	.....	.....	.....	4.72	4.77	4.34	3.95	4.15	4.26	4.68
26	.....	7.68	4.59	4.66	4.66	4.44	3.98	4.20	4.26	4.64
27	.....	.....	.....	4.54	4.60	4.70	3.93	4.15	4.22	4.81
28	.....	.....	.....	4.41	4.68	4.95	3.85	4.10	4.20	6.26
29	.....	.....	.....	4.40	4.62	4.79	3.85	4.20	4.18	4.80
30	.....	.....	4.76	4.54	4.55	5.00	3.86	4.23	4.16	4.75
31	.....	.....	.....	.....	4.47	.....	3.93	4.28	.....	.....

COLUMBUS STATION ON PLATTE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 188, is located on the left bank of the main channel of the river, about 75 feet above the bridge which crosses the channel on the sixth principal meridian near Columbus, Nebraska. The observer is George E. Barnum, a farmer, whose house is about one-half mile from the gage. The gage consists of an inclined oak piece, 3 by 4 inches in section, and 12 feet long. It is fastened to cross-ties, which are bedded, and to stakes which are driven in the bank of the river. The channel is straight both above and below the gage. A round stump on the west side of the road and 80 feet north of the north end of the north truss of the bridge and a square stump directly opposite on the east side of the road were selected as bench marks. The top of the first is 7.38 feet above the zero of the gage, and the top of the second is 7.66 feet above the zero of the gage. Bench mark 3 is the standard 4-foot iron post of the United States Geological Survey and is located 44.5 feet east of gage, 60 feet north of north end of north bridge truss, and 10 feet west of cottonwood tree 6 inches in diameter. Its elevation is 7.06 feet above gage datum. The following discharge measurements were made by Adna Dobson and O. V. P. Stout in 1897:

March 20, gage height, 2.90 feet; discharge, 4,963 second-feet.
April 29, gage height, 3.93 feet; discharge, 8,608 second-feet.
May 5, gage height, 3.79 feet; discharge, 7,322 second-feet.
May 26, gage height, 4.31 feet; discharge, 10,694 second-feet.
June 17, gage height, 4.37 feet; discharge, 12,685 second-feet.
July 11, gage height, 3.05 feet; discharge, 4,001 second-feet.
July 28, gage height, 2.43 feet; discharge, 994 second-feet.
August 17, gage height, 3.18 feet; discharge, 3,343 second-feet.
August 29, gage height, 2.50 feet; discharge, 1,649 second-feet.
October 7, discharge, 2 second-feet.
November 20, gage height, 2.88 feet; discharge, 2,645 second-feet.

Daily gage height, in feet, of Platte River at Columbus, Nebraska, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	4.90	3.90	(a)	(a)	(a)	17	4.30	4.42	2.70	2.70	(a)	(a)
2	.....	4.88	3.90	(a)	(a)	(a)	18	4.40	4.05	(a)	2.80	(a)	(a)
3	.....	4.88	3.82	(a)	(a)	(a)	19	4.40	3.90	(a)	2.80	(a)	(a)
4	3.70	5.15	3.65	(a)	(a)	(a)	20	4.28	3.95	(a)	2.90	(a)	(a)
5	3.75	4.95	3.35	(a)	(a)	(a)	21	4.20	4.20	(a)	2.90	(a)	(a)
6	3.82	4.80	3.18	(a)	(a)	(a)	22	4.20	4.32	(a)	2.90	(a)	(a)
7	3.95	4.80	3.10	(a)	(a)	(a)	23	4.10	4.22	(a)	2.80	(a)	(a)
8	4.10	4.85	3.10	(a)	(a)	(a)	24	4.00	4.18	(a)	2.70	(a)	(a)
9	4.05	4.90	3.10	(a)	(a)	(a)	25	4.15	4.25	(a)	2.60	(a)	(a)
10	4.20	4.95	3.00	(a)	(a)	(a)	26	4.30	4.30	(a)	2.60	(a)	(a)
11	4.15	5.00	2.85	(a)	(a)	(a)	27	4.28	4.30	(a)	2.60	(a)	2.20
12	4.20	5.30	2.70	(a)	(a)	(a)	28	4.48	4.25	(a)	2.60	(a)	2.20
13	4.20	5.20	2.70	(a)	(a)	(a)	29	4.52	4.15	(a)	2.20	(a)	2.25
14	4.20	4.82	2.70	(a)	(a)	(a)	30	4.75	3.95	(a)	2.20	(a)	2.25
15	4.30	4.68	2.70	(a)	(a)	(a)	31	4.80	(a)	(a)	2.20	(a)	(a)
16	4.30	4.58	2.70	(a)	(a)	(a)							

a No water at gage.

NOTE.—August 17 rod found to be loose, and heights subject to change.

NORFOLK STATION ON ELKHORN RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 190, is about 2 miles south of Norfolk, Nebraska, near the line of Thirteenth street extended. The gage is on the left bank of the river. It consists of an inclined oak piece, 2 by 4 inches, 12 feet long, resting on beveled blocks which rest in turn on horizontally bedded cross-ties. All are firmly fastened together by lag screws. The zero of the gage s 8.21 feet below a small spike driven horizontally into a tree near the root, about 20 feet back, and downstream from the gage. Also, the zero of the gage is 3.96 feet below the head of a lag screw which is placed vertically in the horizontal trunk of a large living willow tree which overhangs the stream about 15 feet below the gage. Bench mark 3 is a standard 4 foot iron pipe of the United States Geological Survey, located 35 feet west and 7 feet north of top of gage, and 15.5 feet west of ash tree on which is bench mark 1. Its elevation is 10.70 feet above zero of gage. The observer is Burr Taft, a farmer, whose home is about 300 yards from the gage. The river bed at the station is composed of sand and mud. The following measurements of discharge were made by O. V. P. Stout and Adna Dobson, in 1897:

March 24, gage height, 2.72 feet; discharge, 1,323 second-feet.
May 6, gage height, 2.02 feet; discharge, 647 second-feet.
May 24, gage height, 1.38 feet; discharge, 387 second-feet.
June 21, gage height, 1.03 feet; discharge, 270 second-feet.
July 9, gage height, 0.90 foot; discharge, 212 second-feet.
July 30, gage height, 0.78 foot; discharge 200 second-feet.
August 16, gage height, 0.89 foot; discharge 220 second-feet.
September 2, gage height, 0.68 foot; discharge, 163 second-feet.
October 15, gage height, 0.79 foot; discharge, 168 second-feet.

North Fork:

March 24, discharge, 701 second-feet.
May 6, discharge, 166 second-feet.
May 24, discharge, 77 second-feet.
July 30, discharge, 70 second-feet.

Daily gage height, in feet, of Elkhorn River at Norfolk, Nebraska, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	.....	.....	.....	2.41	1.22	1.21	0.70	0.64	0.63
2	2.90	.....	.....	.....	2.30	1.33	1.21	.75	.67	.62
3	.....	.....	.....	4.06	2.22	1.34	1.12	.80	.63	.60
4	.....	.....	.....	5.95	2.15	1.29	1.08	.81	.61	.61
5	.....	.....	.....	.....	2.05	1.26	1.02	.81	.62	.61
6	.....	2.86	3.01	5.66	2.01	1.26	.96	1.00	.58	.64
7	.....	.....	.....	6.43	1.93	1.24	.95	.91	.57	.64
8	.....	.....	.....	6.93	1.93	1.20	.89	1.06	.56	.70
9	2.52	.....	.....	6.62	2.12	1.16	.88	1.06	.50	.67
10	.....	.....	.....	6.27	1.95	1.16	1.21	1.08	.65	.71
11	.....	.....	.....	5.50	1.86	1.15	1.36	.97	.65	.72
12	.....	.....	.....	5.26	1.80	1.12	1.10	.96	.64	.71
13	.....	2.99	.....	4.90	1.78	1.11	1.02	.90	.64	.85
14	.....	.....	.....	4.52	1.74	1.11	1.00	.96	.64	.85
15	.....	.....	.....	4.28	1.73	1.12	.96	.95	.64	.77
16	2.66	.....	.....	4.08	1.66	1.09	.91	.90	.73	.84
17	.....	.....	.....	3.99	1.65	1.16	.89	.81	.79	.94
18	.....	.....	.....	3.98	1.65	1.15	.86	.86	.78	2.71
19	.....	.....	.....	3.89	1.57	.....	.82	.86	.77	1.02
20	.....	4.24	3.42	3.93	1.52	1.11	1.01	.81	.70	1.00
21	.....	.....	.....	3.87	1.48	1.03	1.02	.76	.77	.98
22	.....	.....	.....	3.72	1.47	1.03	.....	.76	.70	.96
23	2.04	.....	.....	3.56	1.47	1.04	.91	.76	.70	.94
24	.....	.....	.....	3.42	1.38	1.03	.90	.74	.76	.91
25	.....	.....	.....	3.26	1.35	1.00	.86	.75	.70	.94
26	.....	.....	.....	3.10	1.34	1.01	.86	.72	.69	.96
27	.....	3.22	2.24	2.94	.....	1.00	.82	.70	.68	.99
28	.....	.....	.....	2.82	1.31	1.01	.81	.71	.64	1.06
29	.....	.....	.....	2.65	1.26	1.07	.76	.67	.66	1.07
30	2.72	.....	.....	2.51	1.24	1.18	.76	.70	.63	1.09
31	.....	.....	.....	.....	1.22	.....	.76	.64	.....	1.12

WESTERN RIVER STATIONS.

The descriptions of the remaining river stations, mainly within the Rocky Mountain Region, and tables of river height, are printed in Water-supply and Irrigation Paper No. 16, since the publications of this series are limited by the act of June 11, 1896, to 100 pages in length. The results of computations of discharge and facts of general interest are prepared for publication in the Nineteenth Annual Report of this survey, these being accompanied by diagrams, maps, and other illustrations, in form similar to the report of progress of stream measurements for the calendar year 1896, printed in the Eighteenth Annual Report, Part IV.

[For index, see Part II of this report—Water-Supply Paper No. 16.]

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55TH CONGRESS, 2d Session. } HOUSE OF REPRESENTATIVES. { DOCUMENT No. 511.

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 16

OPERATIONS AT RIVER STATIONS, 1897.—PART II

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

OPERATIONS AT RIVER STATIONS, 1897

A REPORT OF THE

DIVISION OF HYDROGRAPHY

OF THE

UNITED STATES GEOLOGICAL SURVEY

PART II

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, February 15, 1898.

SIR: I have the honor to transmit herewith brief descriptions of the river stations at which work was carried on by the Division of Hydrography of this Survey during 1897, together with tables of daily height.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

OPERATIONS AT RIVER STATIONS, 1897.

INTRODUCTION.

Descriptions of river stations in the eastern part of the United States and those on the headwaters of the Missouri and Platte rivers are given in paper No. 15 of this series. The results of the computations of discharge, together with diagrams, maps, and other illustrations, are prepared for publication in the Nineteenth Annual Report of this Survey, in form similar to the results for 1896, given in the Eighteenth Annual Report, Part IV, pp. 1–418. The descriptions of operations at river stations, with accompanying tables of daily gage heights, are printed in this series of Water-Supply and Irrigation Papers in order that the results may be available at as early a date as possible, the preparation and printing of the necessary illustrations for the annual report requiring much time. In order to print these descriptions in this series of papers it has been found necessary to divide them into two parts, as by the act of June 11, 1896 (Stat. L., Vol. XXIX, p. 453), the papers can not exceed 100 pages in length.

The subject-matter of this and the preceding paper has been so arranged as to follow the general geographic order of the drainage basins, beginning at the extreme east and extending southerly along the Atlantic slope, then taking up the headwaters of the Ohio, next the upper Missouri and its great tributary the Platte. This material has been found to occupy the prescribed limit of 100 pages of paper No. 15. In the present paper (No. 16), the stations on the Republican River and other tributaries of Kansas River are taken up; then those on the Arkansas River, Rio Grande, and the tributaries of the great Colorado River west; next the stations on the rivers of the great interior basin; then those on the streams flowing into Columbia River; and finally the stations in California.

SUPERIOR STATION ON REPUBLICAN RIVER.

This station, described in the Eighteenth Annual Report of the United States Geological Survey, Part IV, page 199, is located about 1 mile west of Superior, Nebraska. It is on the left bank of the river, about 25 feet above the iron highway bridge. A dam and the head of a mill race are only a short distance below the bridge. The observer is

T. C. Sheffer. The gage consists of an oak piece 2 by 4 inches, 10 feet long. The face is inclined 30 degrees to the horizontal, and the foot-marks are placed 2 feet apart to correspond to this inclination. The rod is fastened to cross-ties which are bedded in the bank of the river. The location is on the outside of an easy bend in the river. The bed of the river is of mud and sand. The top of the rim of the upstream cylinder of the north pier is 15.42 feet above zero of the gage. Bench mark 2 is the standard 4-foot iron pipe of the United States Geological Survey. It is 83 feet north of the upstream cylinder of the north pier of the bridge and is 10 feet west of the line of the upstream truss of the bridge. It is 1 foot inside a wire fence. The top of the pipe is 4 inches above the ground and the elevation is 4.88 feet above gage datum. The following measurements were made in 1897 by Adna Dobson and O. V. P. Stout:

April 12, gage height, 1.12 feet; discharge, 1,257 second-feet.
April 24, gage height, 0.99 foot; discharge, 887 second-feet.
May 18, gage height, 0.45 foot; discharge, 337 second-feet.
June 12, gage height, 0.72 foot; discharge, 716 second-feet.
July 8, gage height, 0.87 foot; discharge, 766 second-feet.
July 18, gage height, 0.32 foot; discharge, 222 second-feet.
August 6, gage height, 0.49 foot; discharge, 372 second-feet.
August 22, gage height, — 0.05 foot; discharge, 195 second-feet.
September 25, gage height, 0.04 foot; discharge, 81 second-feet.
October 24, gage height, 0.02 foot; discharge, 184 second-feet.

Daily gage height, in feet, of Republican River at Superior, Nebraska, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	1.01	.....	.....	0.87	0.28	1.48	0.08	0.12	—0.12
2	0.75	1.01	0.84	0.97	.77	.27	.75	.12	.06	— .34
3	.80	1.01	.....	.....	.69	.32	1.65	.08	.01	.00
4	.80	1.01	.....	1.00	.67	.32	1.39	.07	— .06	— .35
5	.80	1.01	.....	1.67	.64	.27	1.35	.12	+ .04	— .30
6	.80	1.01	.70	1.50	.66	.36	2.15	.48	.03	— .58
7	.80	1.01	.70	1.05	.63	.54	1.64	.20	.01	— .30
8	.80	1.01	.....	1.18	.60	.40	1.80	.57	— .20	— .52
9	.80	1.01	.....	1.12	.77	.34	1.48	.56	— .25	— .71
10	.80	1.01	.64	1.08	.80	.31	1.06	.45	— .16	— .50
11	.80	1.01	.....	1.09	.66	.92	.94	.45	— .02	— .35
12	.80	1.01	.....	1.12	.62	.74	.70	.56	+ .20	— .30
13	.80	1.01	.....	1.14	.60	.54	.51	.54	.60	— .53
14	.80	.....	.....	1.07	.54	.71	.39	.55	.00	— .56
15	.80	1.01	.71	1.09	.52	.48	.34	.10	.01	— .90
16	.80	.....	.....	1.62	.50	.76	.28	.14	.36	+ .04
17	.....	.....	.55	1.31	.48	.79	.28	.14	.26	1.22
18	.....	.....	.....	1.14	.45	.74	.32	.18	.26	1.30
19	.....	1.00	.....	1.08	.42	.66	.25	.21	.15	1.25
20	.90	.....	.61	1.05	.38	.68	.34	.31	.10	1.19
21	.....	.60	.....	1.03	.35	.58	.30	.24	.05	1.11
22	.....	.....	.86	1.02	.37	.47	.22	.30	.04	1.10
23	1.01	.....	.65	.92	1.10	.43	.66	.27	— .05	1.11
24	1.01	.....	.....	1.00	.63	.48	.69	.57	+ .01	— .05
25	1.01	1.22	.....	.98	.61	.33	.15	.50	.02	+1.06
26	1.01	.....	.....	.88	.57	2.42	.23	.39	— .25	1.08
27	1.01	.....	.64	.82	.63	4.38	.16	.31	— .12	2.45
28	1.01	.....	.....	1.32	.42	1.87	.84	.26	— .09	2.32
29	1.01	.....	.....	1.20	.40	1.78	.30	.23	— .06	1.53
30	1.01	.....	.....	.98	.32	1.72	.17	.14	— .05	1.45
31	1.01	.....	.81	.....	.27	.....	.14	.11	.....	.....

JUNCTION CITY STATION ON REPUBLICAN RIVER.

This station, as described in the Eighteenth Annual Report, Part IV, page 203, is located at the wagon bridge at the north end of Washington street, Junction City, Kansas. The observer is John Davis. The gage consists of two oak timbers bolted to a post and to a cottonwood tree. One bench mark consists of a 60-penny nail driven into the base of the abutment at an elevation of 10.67 feet on the scale. A second bench mark is the top of the stone in the base of the bridge abutment, 18 feet south of the gage; its elevation is 14.51 feet. A subsidiary gage for determining the slope has been placed 507 feet upstream, and referred to the same datum. The right bank is high, but the left is low and may overflow in high water. The bed of the stream is sandy and changeable. The following are the discharge measurements made in 1897 by W. G. Russell:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Feb. 23	4.30	1,021	May 21	3.10	725	July 28	4.45	1,367
Mar. 23	3.80	611	June 1	3.70	869	Aug. 18	4.20	1,243
Apr. 7	4.30	1,015	June 16	6.30	3,637	Sept. 30	2.30	175
Apr. 20	4.90	1,433	June 30	7.40	6,053	Oct. 26	2.80	313
Apr. 27	6.10	3,565	July 13	5.95	3,141	Nov. 12	3.50	616
May 6	3.60	1,078						

Daily gage height, in feet, of Republican River at Junction City, Kansas for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.70	3.40	3.80	4.00	4.40	3.65	6.15	2.95	2.75	2.30	4.15	2.70
2	3.80	3.40	3.70	4.00	4.40	3.35	6.50	3.45	2.60	2.30	3.60	2.80
3	3.95	3.55	3.65	4.00	4.35	3.15	6.40	3.00	2.55	2.30	3.40	3.10
4	3.80	3.85	3.95	4.05	4.20	3.05	5.65	2.85	2.50	2.20	3.30	3.20
5	3.80	4.00	4.05	4.10	3.95	2.95	5.05	3.40	2.50	2.20	3.35	3.30
6	3.70	4.05	3.85	4.15	3.70	2.85	4.90	3.60	2.50	2.20	3.40	3.30
7	3.70	4.15	3.80	4.25	3.50	2.80	4.70	3.05	2.50	2.20	3.40	3.30
8	3.60	4.15	3.85	4.55	3.50	2.80	4.50	2.85	2.35	2.20	3.40	3.30
9	3.65	4.20	4.20	4.60	3.40	2.70	4.65	2.75	2.30	2.20	3.50	3.40
10	3.55	4.25	4.05	4.70	3.35	2.70	7.05	2.70	2.35	2.20	3.50	3.50
11	3.45	4.25	3.90	4.60	3.55	2.70	7.50	2.85	2.50	2.20	3.50	3.40
12	3.45	4.20	3.90	4.70	3.55	2.90	7.25	3.60	2.30	2.20	3.50	3.45
13	3.50	4.55	3.90	4.60	3.40	4.55	5.80	3.35	2.30	2.20	3.50	3.55
14	3.55	4.85	3.80	4.45	3.45	6.25	5.00	3.55	2.30	2.15	3.50	3.50
15	3.35	4.80	3.70	4.45	3.55	5.60	4.30	4.80	2.30	2.10	3.45	3.50
16	3.45	4.80	3.70	4.45	3.60	6.15	3.90	5.25	2.30	2.20	3.40	3.60
17	3.60	5.00	3.60	4.45	3.50	5.70	3.65	5.00	2.30	2.40	3.40	3.60
18	3.60	5.85	3.80	4.40	3.40	6.05	3.45	4.15	2.30	2.40	3.40	3.60
19	3.50	5.20	3.85	4.40	3.35	5.70	3.30	4.35	2.30	2.40	3.40	3.60
20	3.65	5.15	3.90	4.80	3.15	4.90	3.15	3.30	2.30	2.55	3.40	3.50
21	3.60	4.80	3.80	4.80	3.10	5.00	3.05	3.00	3.05	2.85	3.40	3.40
22	3.70	4.35	3.75	4.65	3.05	4.35	3.25	2.85	3.25	3.00	3.40	3.50
23	4.20	4.20	3.75	4.55	2.95	4.05	3.30	2.70	3.05	3.00	3.40	3.50
24	3.50	4.30	3.75	7.20	2.80	4.55	3.05	2.70	2.75	3.00	3.35	3.50
25	3.50	4.20	3.70	7.95	2.80	5.25	3.20	2.65	2.60	2.90	3.30	3.60
26	3.50	4.40	3.90	7.35	2.80	5.10	3.30	2.60	2.50	2.80	3.40	3.55
27	3.40	4.10	3.90	6.20	3.55	3.95	3.35	2.60	2.40	2.90	3.40	3.65
28	3.40	3.85	3.90	5.70	4.55	3.80	4.40	2.60	2.40	2.80	3.35	3.80
29	3.35	.....	3.90	5.05	5.50	5.70	3.90	2.85	2.35	2.80	2.85	3.90
30	3.30	.....	3.90	4.70	4.75	7.40	3.40	2.90	2.30	2.80	2.70	3.80
31	3.30	.....	3.90	.....	4.15	.....	3.15	2.80	.....	2.90	.....	3.80

BELOIT STATION ON SOLOMON RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 207, is located at the wagon bridge on the south edge of the town of Beloit, Kansas. The observer is W. F. Jordon. The rod of the wire gage is a spruce board, 12 feet long, graduated in feet and tenths, spiked to the upstream edge of the bridge floor, over the deepest water. The bench mark consists of a tenpenny nail driven into the base of a cottonwood tree 35 feet northwest of the pier upon which the marks are made. Its elevation is 13.70 feet. Measurements were made from the bridge, the initial point being at the south edge of the stone abutment on the left bank of the stream. This station was discontinued on June 30, 1897, as a more favorable location was found at Niles, and a station was therefore established at the latter place. The following discharge measurements were made in 1897 by W. G. Russell:

February 23, gage height, 3.50 feet; discharge, 102 second-feet.
March 23, gage height, 2.70 feet; discharge, 24 second-feet.
April 7, gage height, 4.20 feet; discharge, 508 second-feet.
April 20, gage height, 3.55 feet; discharge, 247 second-feet.
April 28, gage height, 3.40 feet; discharge, 270 second-feet.
May 20, gage height, 3.10 feet; discharge, 197 second-feet.
June 15, gage height, 7.80 feet; discharge, 2,565 second-feet.

Daily gage height, in feet, of Solomon River at Beloit, Kansas, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	Day.	Jan.	Feb.	Mar.	Apr.	May.	June.
1....	3.20	3.25	3.65	3.65	3.70	2.55	17.....	2.80	3.65	3.35	3.45	3.15	15.00
2....	3.20	2.95	3.45	3.60	3.55	2.75	18.....	3.40	3.90	3.60	3.30	3.15	5.20
3....	2.45	3.40	3.45	3.70	3.45	3.00	19.....	3.45	3.60	3.35	3.50	3.05	3.90
4....	3.10	2.60	3.65	5.30	3.45	2.75	20.....	3.45	3.55	3.60	3.35	3.00	3.65
5....	2.40	3.40	3.65	4.70	3.30	2.90	21.....	3.40	3.15	3.10	3.60	3.05	3.65
6....	3.15	3.40	3.70	4.55	3.25	2.60	22.....	3.40	3.50	3.60	3.60	2.90	4.00
7....	2.85	2.60	3.10	4.05	3.25	2.65	23.....	3.40	3.45	3.15	3.60	2.90	8.05
8....	3.05	3.40	3.40	3.90	3.40	2.75	24.....	2.95	3.45	3.45	7.10	3.65	4.00
9....	3.05	3.35	3.65	4.45	3.05	2.70	25.....	2.95	3.45	3.60	8.90	3.85	6.00
10....	2.85	3.35	3.35	4.20	3.20	2.75	26.....	3.45	3.40	3.05	3.55	3.20	3.90
11....	3.40	3.45	3.50	4.05	3.30	4.85	27.....	3.35	3.50	3.50	3.50	3.00	14.75
12....	3.10	3.55	3.45	4.05	3.55	11.55	28.....	3.40	2.60	3.25	3.45	2.50	22.35
13....	3.30	3.40	3.45	3.80	3.30	6.70	29.....	2.90	.....	3.70	3.65	3.00	19.45
14....	2.75	3.00	3.10	3.65	3.25	3.55	30.....	3.35	.....	3.65	3.95	2.60	5.25
15....	3.20	3.40	3.35	3.65	3.10	12.10	31.....	2.55	.....	3.65	.....	3.00	.....
16....	3.40	3.45	3.45	3.40	3.10	23.25							

NILES STATION ON SOLOMON RIVER.

This station is located at a bridge one-half mile west of Niles, Kansas, and was established May 5, 1897. The rod of the wire gage is spiked to the floor of the bridge. It is 1 by 4 inches by 24 feet long. The bench mark is the upper one of three nails driven into a cottonwood tree 18 inches in diameter, north side of the river and 25 feet east of the bridge. Its elevation is 24.96 feet above gage datum. The initial point for soundings is on the right bank. The channel is straight for about 100 feet above and below the section. The current is sluggish. The right bank is high, and the left bank overflows only in very high water. The bed of the stream is muddy. The observer is J. J. Little. The following discharge measurements were made in 1897 by W. G. Russell:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
May 5....	6.60	386	June 17 ...	13.55	2,083	July 28 ..	5.80	193
May 20...	5.70	253	June 18 ...	16.95	3,159	Aug. 18 ..	5.60	193
June 1 ...	5.30	179	June 18 ...	18.25	3,701	Sept. 30 ..	4.80	95
June 15 ..	13.60	1,898	July 1.....	20.70	4,856	Oct. 25...	4.50	83
June 16 ..	9.40	974	July 13....	7.55	451	Nov. 12 ..	4.80	96

Daily gage height, in feet, of Solomon River at Niles, Kansas, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	5.35	20.95	6.40	4.80	4.80	4.90	5.30
2	.....	5.20	21.17	6.15	4.95	4.70	4.85	5.15
3	.....	5.15	13.35	5.95	4.95	4.55	4.80	5.15
4	.....	5.15	8.95	5.80	4.80	4.50	5.25	5.20
5	.....	5.20	9.00	5.70	4.85	4.30	5.15	5.20
6	6.45	5.15	8.55	6.05	4.85	4.75	5.10	5.25
7	6.10	5.10	7.80	5.75	4.75	4.65	5.15	5.15
8	6.02	5.05	7.35	5.50	4.75	4.50	5.00	5.15
9	6.05	5.10	7.10	5.35	4.65	4.60	4.85	5.20
10	6.20	5.10	8.95	5.65	4.60	4.55	4.90	5.25
11	6.35	5.05	10.40	5.45	4.60	4.80	5.00	5.20
12	5.80	4.80	9.80	5.35	4.65	4.35	4.95	5.30
13	6.05	4.80	7.85	5.50	4.55	4.80	4.85	.....
14	6.15	9.70	7.45	5.40	4.50	4.65	4.95	.....
15	6.50	13.50	8.05	5.80	4.55	4.65	4.60	.....
16	6.05	8.80	7.10	6.20	4.90	4.55	4.60	.....
17	6.00	10.90	6.60	5.90	4.70	4.70	4.80	.....
18	5.85	17.45	6.35	5.65	4.55	4.65	4.90	5.00
19	5.85	20.00	6.25	5.65	4.40	4.55	4.90	5.00
20	5.80	17.85	6.20	5.60	4.60	5.10	4.95	.....
21	5.60	9.25	6.05	5.40	4.45	5.15	5.00	.....
22	5.55	8.65	6.10	5.35	5.05	4.90	4.85	.....
23	5.45	7.70	5.90	5.30	5.60	4.80	4.80	.....
24	5.30	8.70	5.80	5.20	5.40	4.70	4.80	.....
25	5.30	11.25	5.70	5.20	5.25	4.75	4.90	5.30
26	5.35	13.50	5.85	5.25	5.10	4.75	4.75	5.30
27	6.70	11.10	5.85	5.15	4.90	4.75	4.90	.....
28	8.30	9.15	5.90	5.05	4.95	4.90	4.95	.....
29	6.50	12.90	6.95	4.95	4.75	5.05	4.60	.....
30	5.85	18.50	8.00	4.85	4.80	4.95	4.90	.....
31	5.55	.....	7.00	.....	.....	4.95	.....	5.30

BEVERLY STATION ON SALINE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 210, is located at the iron highway bridge one-half mile southwest of Beverly, Kansas. The observer is Jerome Wilson, who lives about one-half mile from the station. The gage is an inclined timber, fastened to trestles which are set in the ground and well loaded down with rock. It is graduated up to 18 feet, and one of the iron cylinder bridge piers is then graduated up to 30 feet. The bench mark is the top of the lower iron strut at the north end connecting the two south piers. Its elevation is 18.95 feet above the zero of the gage. This station was discontinued on June 30, 1897, as a more favorable location was found at Salina, and a station was therefore established at the latter place. The following measurements of discharge were made in 1897 by W. G. Russell:

February 24, gage height, 4.70 feet; discharge, 67 second-feet.
March 26, gage height, 4.60 feet; discharge, 53 second-feet.
April 15, gage height, 5.40 feet; discharge, 161 second-feet.
April 30, gage height, 5.80 feet; discharge, 196 second-feet.
June 2, gage height, 4.80 feet; discharge, 75 second-feet.

Daily gage height, in feet, of Saline River at Beverly, Kansas, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	Day.	Jan.	Feb.	Mar.	Apr.	May.	June.
1	4.45	.....	4.40	4.65	7.05	4.80	17	4.75	4.95	4.60	5.25	5.20	4.45
2	4.55	4.20	4.60	4.55	7.05	4.70	18	4.35	5.15	4.50	5.15	5.15	4.45
3	4.80	.....	4.70	4.55	6.20	4.75	19	4.75	4.95	4.55	5.10	5.10	4.65
4	4.35	4.30	4.70	4.65	5.95	4.60	20	4.60	4.85	4.35	5.05	5.05	4.50
5	4.25	.....	4.20	7.85	5.75	4.75	21	4.75	4.75	4.45	5.05	5.00	4.45
6	4.45	4.40	4.55	8.80	5.65	4.75	22	4.70	4.70	4.30	5.00	4.95	4.55
7	4.35	.....	4.50	6.40	5.55	4.70	23	4.70	4.75	4.60	5.00	4.90	4.55
8	4.20	.....	4.65	5.95	5.55	4.60	24	4.60	4.55	4.45	6.00	4.90	4.40
9	4.55	.....	4.60	5.95	5.50	4.75	25	4.60	4.65	4.45	7.20	4.85	4.40
10	4.35	4.40	4.55	6.50	5.45	4.50	26	3.90	4.70	4.45	5.35	4.85	4.45
11	4.50	5.00	4.50	6.65	5.50	4.55	27	3.90	4.75	4.45	5.45	4.85	7.70
12	4.70	4.70	4.65	6.10	5.45	4.60	28	3.90	4.50	4.50	5.45	4.80	17.50
13	4.60	5.30	4.50	5.75	5.50	4.50	29	4.20	.....	4.40	5.45	4.70	7.85
14	5.05	6.15	4.50	5.55	5.50	4.55	30	4.20	.....	4.40	5.80	4.70	5.35
15	4.60	5.40	4.35	5.45	5.50	4.55	31	4.30	.....	4.70	.....	4.60	.....
16	4.65	5.00	4.35	5.35	5.25	4.55							

SALINA STATION ON SALINE RIVER.

This station is located at a bridge 4.5 miles northeast of Salina, Kansas. The rod of the wire gage is spiked to the floor of the bridge. It is 1 by 4 inches, and 24 feet long. Bench mark 1 is a nail in an elm 2 feet in diameter, on the north side of the river and 6 feet west of the bridge, and its elevation is 22.90 feet above gage datum. Bench mark 2 is six nails driven into a 16-inch box elder on north side of river and 35 feet east of the bridge. Its elevation is 22.90 feet above datum. The channel is straight for a little distance above and below the station. Both banks are high, and are not liable to overflow. The bed of the stream is sandy and muddy. The observer is H. W. Barr. The following discharge measurements were made during 1897 by W. G. Russell:

May 4, gage height, 7.00 feet; discharge, 333 second-feet.
May 17, gage height, 4.90 feet; discharge, 135 second-feet.
May 31, gage height, 3.90 feet; discharge, 73 second-feet.
June 18, gage height, 3.50 feet; discharge, 60 second-feet.
June 28, gage height, 3.20 feet; discharge, 45 second-feet.
July 14, gage height, 3.40 feet; discharge, 54 second-feet.
July 26, gage height, 3.30 feet; discharge, 51 second-feet.
August 19, gage height, 4.90 feet; discharge, 152 second-feet.
September 28, gage height, 2.80 feet; discharge, 26 second-feet.
October 20, gage height, 2.50 feet; discharge, 17 second-feet.
November 11, gage height, 2.90 feet; discharge, 29 second-feet.

Daily gage height, in feet, of Saline River at Salina, Kansas, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.70	9.50	3.00	3.10	2.50	3.15	3.15
2	.....	3.70	5.10	3.05	3.05	2.45	3.15	3.05
3	.....	3.75	4.40	3.15	3.00	2.60	2.85	3.10
4	7.00	3.75	4.10	3.25	3.05	2.60	3.10	3.15
5	6.35	3.65	3.90	3.05	3.10	2.60	2.80	3.10
6	5.90	3.80	3.85	3.05	3.05	2.50	2.85	3.20
7	5.65	3.60	3.70	3.05	3.00	2.50	3.00	3.05
8	5.40	3.75	3.70	3.05	3.00	2.50	2.95	3.15
9	5.30	3.75	3.60	2.95	2.95	2.45	3.10	3.15
10	5.25	3.75	3.75	2.85	2.85	2.55	3.00	3.15
11	5.15	3.75	3.95	3.05	2.80	2.75	3.05	2.85
12	5.10	3.70	3.85	3.15	2.75	2.80	3.15	2.95
13	5.15	3.50	3.70	3.10	2.65	2.70	3.05	3.20
14	5.10	3.55	3.45	3.30	2.65	2.55	2.95	3.25
15	5.05	3.55	3.35	3.45	2.65	2.55	3.05	3.15
16	5.00	3.50	3.40	3.40	2.85	2.65	2.95	3.15
17	4.90	3.55	3.35	7.35	3.45	2.90	3.05	(a)
18	4.55	3.55	3.45	6.75	2.95	2.80	2.95	.....
19	4.70	3.50	3.25	4.80	2.90	2.65	3.05	.....
20	4.65	3.45	3.20	4.15	2.90	2.65	3.10	3.10
21	4.50	3.45	3.80	3.85	2.85	3.35	3.10	.....
22	4.45	3.45	3.40	3.90	2.75	3.70	3.05	.....
23	4.35	3.45	3.10	4.00	2.80	3.50	3.10	.....
24	4.25	3.30	3.00	3.80	2.85	3.55	3.05	3.10
25	4.25	3.50	3.00	3.50	2.75	3.60	3.10	.....
26	4.10	3.55	3.20	3.50	2.90	3.40	3.05	.....
27	4.05	3.35	3.15	3.50	2.75	3.45	3.25	.....
28	4.10	3.30	3.00	3.35	2.75	3.45	3.15	3.20
29	4.05	11.15	3.05	3.30	2.75	3.10	3.15	.....
30	3.90	14.90	3.00	3.30	2.70	3.05	3.20	.....
31	3.85	.....	3.05	3.10	.....	3.15	.....	3.20

a Frozen.

ELLSWORTH STATION ON SMOKY HILL RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 212, is located at the highway bridge on Douglas avenue, Ellsworth, Kansas. The observer is Robert Martin, who lives about 100 yards north of the bridge. The gage is an inclined ash timber spiked to a post driven in the bed of the river and bolted to an iron post of the bridge pier. The bench mark is a nail driven in the base of a large box-elder tree near the southeast corner of the bridge, 90 feet from the gage, and its elevation is 13.07 feet above the zero. A slope gage is spiked to the Frisco railroad bridge 2,536 feet upstream and is referred to same datum. The channel is nearly straight above and below the bridge, and the bed is sandy and shifting. The following discharge measurements were made by W. G. Russell in 1897.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Feb. 26	1.30	40	May 17	1.80	167	Aug. 17	1.60	84
Mar. 29	1.15	30	June 4	1.30	57	Aug. 24	2.30	301
Apr. 6	2.30	287	June 28	1.40	79	Sept. 24	1.25	57
Apr. 23	1.45	80	July 15	1.30	43	Oct. 19	1.40	77
May 8	1.70	141	July 26	1.20	38	Nov. 9	1.30	49

Daily gage height, in feet, of Smoky Hill River at Ellsworth, Kansas, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.20	1.40	1.40	1.20	2.60	1.40	1.35	1.38	1.45	1.00	1.10	1.20
2	1.10	1.40	1.30	1.25	2.35	1.35	1.30	1.45	1.40	1.00	1.20	1.10
3	1.30	1.45	1.20	1.35	2.25	1.30	1.25	1.30	1.35	1.00	1.30	1.10
4	1.35	1.50	1.30	2.10	2.05	1.30	1.20	1.20	1.30	.95	1.40	1.10
5	1.20	1.50	1.30	2.60	1.85	1.30	1.20	1.20	1.25	.95	1.35	1.10
6	1.20	1.55	1.30	2.30	1.80	1.30	1.15	1.15	1.30	.95	1.35	1.10
7	1.25	1.70	1.30	2.15	1.70	1.30	1.10	1.20	1.15	.90	1.35	1.10
8	1.35	1.65	1.30	2.15	1.65	1.40	1.10	1.15	1.10	.90	1.30	1.15
9	1.45	1.60	1.25	2.15	1.70	1.30	1.05	1.10	1.10	.90	1.30	1.15
10	1.40	2.00	1.25	2.15	1.65	1.30	1.20	1.10	1.10	.90	1.30	1.15
11	1.40	1.85	1.20	2.05	1.85	1.30	1.20	1.00	1.10	.90	1.25	1.20
12	1.45	1.55	1.20	1.95	2.10	1.25	1.15	1.00	1.05	.90	1.25	1.20
13	1.30	2.00	1.15	1.80	2.20	1.20	1.15	1.15	1.00	.90	1.25	1.15
14	1.75	1.85	1.15	1.70	2.15	1.20	1.10	1.45	1.00	.90	1.25	1.10
15	1.60	1.75	1.15	1.65	2.05	1.20	1.20	1.80	1.05	.90	1.20	1.15
16	1.25	1.65	1.15	1.60	1.85	1.50	1.25	1.70	1.65	1.00	1.15	1.15
17	1.35	1.95	1.20	1.60	1.75	2.10	1.20	1.60	1.25	1.50	1.15	1.05
18	1.25	2.00	1.20	1.55	1.70	2.10	1.20	1.50	1.20	1.45	1.15	1.10
19	1.40	1.85	1.15	1.50	1.60	1.85	1.15	1.40	1.15	1.40	1.20	1.20
20	1.40	1.70	1.15	1.50	1.50	1.80	1.23	1.30	1.25	1.40	1.20	1.20
21	1.40	1.55	1.10	1.45	1.50	1.70	1.13	1.20	1.40	1.35	1.20	1.20
22	1.45	1.40	1.10	1.45	1.60	1.55	1.10	1.15	1.35	1.30	1.20	1.20
23	1.55	1.45	1.10	1.45	2.15	1.45	1.05	2.15	1.30	1.30	1.15	1.20
24	1.35	1.40	1.10	1.50	1.95	1.40	1.15	2.30	1.35	1.25	1.20	1.20
25	1.35	1.40	1.10	1.55	1.75	1.50	1.25	2.15	1.20	1.25	1.15	1.20
26	1.30	1.35	1.10	1.50	1.60	1.50	1.20	1.95	1.15	1.25	1.10	1.25
27	1.35	1.20	1.10	1.55	1.55	1.45	1.20	1.85	1.10	1.25	1.00	1.35
28	1.35	1.35	1.10	1.60	1.50	1.40	1.25	1.75	1.10	1.20	1.00	1.35
29	1.35	.....	1.15	1.85	1.50	1.35	1.35	1.65	1.05	1.15	1.00	1.40
30	1.40	.....	1.15	2.30	1.50	1.30	1.50	1.60	1.00	1.15	1.00	1.45
31	1.40	.....	1.20	.....	1.45	.....	1.45	1.53	.....	1.10	.....	1.55

MANHATTAN STATION ON BLUE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 215, is located at the county bridge 4 miles north of Manhattan, Kansas. The gage consists of three sections, the lower being an ash stick driven into the bottom of the river and bolted to an overhanging cottonwood tree 30 feet east of the bridge, and marked from 2.10 to 11.30 feet. The middle section consists of an oak stick bolted to the north side of the south bridge pier and marked from 11.30 to 17 feet. A similar stick on the south side of the same pier, and marked from 17 to 30 feet, completes the gage. The bench mark is a cross cut in the capstone of the south bridge pier immediately above the upper gage, and is 32.135 feet above datum. The observer is William Hudspeth. The following discharge measurements were made in 1897 by O. P. Hood and S. R. Vincent:

April 26, gage height, 25.45 feet; discharge, 31,942 second-feet.
April 30, gage height, 10.80 feet; discharge, 5,972 second-feet.
October 30, gage height, 4.00 feet; discharge, 602 second-feet.
December 8, gage height, 4.20 feet; discharge, 499 second-feet.

Daily gage height, in feet, of Blue River at Manhattan, Kansas, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.00	5.40	6.00	8.75	9.70	6.75	8.75	5.20	4.90	3.55	4.00	4.40
2	4.10	5.10	6.00	16.50	10.30	6.55	7.90	5.05	4.65	3.50	4.00	4.30
3	4.10	5.00	5.80	17.25	9.95	6.40	7.25	4.90	4.55	3.50	3.80	4.25
4	4.25	4.90	5.70	11.50	9.15	6.25	7.00	4.00	4.35	3.40	3.70	4.20
5	4.60	4.55	5.55	10.90	7.95	5.90	6.80	4.70	4.25	3.40	3.80	4.10
6	4.80	4.35	5.00	10.30	7.80	5.70	6.50	5.35	4.05	3.40	3.90	4.10
7	4.90	4.25	4.80	9.75	7.60	5.60	6.20	6.15	3.80	3.30	4.00	4.00
8	4.85	4.00	4.75	8.75	7.50	5.50	6.00	8.85	3.70	3.30	4.00	4.20
9	4.80	4.05	4.65	8.20	7.25	5.40	7.50	8.55	3.60	3.20	4.10	4.30
10	4.60	4.25	5.10	7.90	6.85	5.00	8.35	7.50	3.50	3.20	4.25	4.25
11	4.60	4.35	5.30	7.40	6.75	4.75	10.40	7.15	3.30	3.15	4.25	4.20
12	4.80	4.50	5.45	7.10	6.75	4.55	12.75	6.25	2.50	3.05	4.25	4.25
13	4.85	4.90	5.65	6.90	7.05	4.50	12.25	6.00	2.30	3.00	4.40	4.30
14	4.90	5.65	6.60	6.70	7.10	4.80	9.65	5.75	2.30	3.00	4.50	4.15
15	4.80	5.90	7.15	6.40	6.85	4.95	9.00	6.90	2.75	3.65	4.45	4.00
16	4.75	6.00	6.85	6.00	6.75	5.40	8.50	8.10	3.35	4.00	4.35	4.00
17	4.70	6.25	6.65	5.75	6.35	5.60	8.10	7.90	3.75	4.15	4.30	4.10
18	4.80	6.80	6.35	5.60	6.20	5.90	7.90	7.50	3.85	4.25	4.20	4.15
19	4.85	7.20	6.10	5.50	6.10	6.20	7.10	7.35	4.25	4.35	4.20	4.20
20	4.90	6.65	5.80	5.45	6.00	8.90	6.10	7.05	4.60	4.40	4.10	4.20
21	5.15	6.30	5.75	5.40	5.90	8.75	5.70	6.65	4.50	4.30	4.05	4.35
22	5.00	6.10	5.65	5.50	5.80	8.00	5.55	6.45	4.30	4.25	4.00	4.50
23	4.95	6.00	5.60	9.25	5.75	7.50	5.20	6.35	4.25	4.20	4.05	4.50
24	4.85	5.90	5.50	20.95	5.95	7.00	5.00	6.30	4.15	4.40	4.20	4.60
25	4.80	5.75	5.40	24.15	5.80	7.70	7.20	6.15	4.00	4.30	4.25	4.60
26	5.50	5.65	5.35	25.30	5.85	7.00	6.90	6.05	4.00	4.25	4.30	4.60
27	5.50	5.50	5.30	25.60	6.70	14.55	6.65	5.75	3.90	4.20	4.40	4.60
28	5.50	5.80	6.25	19.65	7.85	19.45	6.10	5.60	3.85	4.30	4.40	4.55
29	5.50	.....	6.85	12.00	7.60	13.40	5.90	5.40	3.80	4.35	4.50	4.40
30	5.55	.....	6.95	10.75	6.80	9.80	5.55	5.25	3.60	4.40	4.50	4.40
31	5.60	.....	7.15	.....	6.85	.....	5.40	5.05	.....	4.40	.....	4.50

LAWRENCE STATION ON KANSAS RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 219, is located at Lawrence, Kansas. The gage consists of a vertical board marked to feet and tenths and fastened to the south pier of the carriage bridge, about 50 feet up the river from the crest of a dam. The zero of the gage is on a level with a large stone in the crest of dam. There is also a short vertical board fastened by the side of this one for reading the level of the water when it stands below the zero of the gage. The channel is about 690 feet wide, broken by four piers. The observer is J. D. Bowersock. The following is a list of discharge measurements made in 1897 by E. C. Murphy:

April 9, gage height, 2.55 feet; discharge, 10,238 second-feet.
April 10, gage height, 2.55 feet; discharge, 9,658 second-feet.
April 26, gage height, 9.10 feet; discharge, 60,854 second-feet.
June 17, gage height, 1.50 feet; discharge, 4,820 second-feet.
June 23, gage height, 2.73 feet; discharge, 10,635 second-feet.
June 25, gage height, 2.10 feet; discharge, 8,011 second-feet.

Daily gage height, in feet, of Kansas River at Lawrence, Kansas, for 1897

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.80	0.80	1.20	2.65	3.60	1.90	5.30	1.40	0.60	0.10	0.60	—1.60
2	.80	.70	1.10	2.80	3.10	1.70	4.65	1.20	.60	.20	.60	—1.70
3	1.00	.70	1.10	3.60	2.70	1.50	3.40	1.00	.60	.40	.60	—1.70
4	.60	.60	1.10	2.70	2.30	1.40	3.20	1.00	.60	.40	.60	—1.40
5	.40	.60	1.10	2.40	2.40	1.40	0.80	.80	.60	.25	.60	— .90
6	.50	.60	1.00	2.40	2.30	1.20	5.50	.80	.60	.10	.80	— .50
7	.60	.80	1.15	2.35	2.05	1.00	4.15	.80	.40	.10	.80	— .30
8	.60	.80	1.15	1.95	2.00	1.00	3.50	1.40	.40	.20	.90	+ .10
9	.60	1.00	1.05	2.55	2.00	1.00	2.70	1.80	.40	.10	.90	.10
10	1.00	1.00	1.00	2.60	1.95	1.00	2.00	1.80	.40	.15	.90	.20
11	1.00	1.00	1.00	2.40	1.80	1.00	1.90	1.60	.40	.30	.80	.40
12	1.00	1.00	1.00	2.10	1.75	1.00	2.40	1.20	.40	.20	.80	.40
13	1.00	1.10	1.00	2.00	1.65	1.00	3.70	1.20	.40	.60	.80	.20
14	.80	1.70	1.20	1.95	1.60	1.00	3.90	1.00	.30	.70	1.00	.10
15	.80	1.90	1.20	1.90	1.60	.90	3.40	1.00	.20	.70	.90	— .20
16	.90	1.90	1.35	2.00	1.60	1.10	2.70	1.00	.20	.10	.80	— .70
17	1.00	2.30	1.40	2.05	1.60	1.45	2.00	1.30	.10	.10	.80	—1.00
18	1.00	2.90	1.50	1.65	1.60	1.50	1.70	1.80	.10	.10	.80	—1.00
19	1.00	3.00	1.60	1.60	1.45	2.00	1.60	1.50	.25	.00	.80	+ .10
20	.90	2.65	1.60	1.55	1.40	1.80	1.40	1.75	.10	.20	.80	— .40
21	1.00	2.60	1.40	1.45	1.40	2.00	1.35	1.20	.40	.20	.80	— .50
22	1.00	2.30	1.40	1.40	1.40	3.00	1.30	1.20	.40	.20	.80	— .60
23	1.00	2.15	1.20	1.45	1.35	2.80	1.20	1.00	.40	.30	.80	— .60
24	1.00	1.90	1.30	1.45	1.20	2.60	1.20	.70	.25	.40	.80	— .40
25	.60	1.60	1.25	6.30	1.20	2.05	1.10	.60	.20	.40	.80	— .20
26	.20	1.40	1.20	8.80	1.20	2.80	1.20	.60	.40	.40	.60	+ .40
27	.30	1.20	1.20	7.60	1.20	3.50	1.40	.55	.40	.50	.40	— .10
28	.60	1.30	1.20	7.60	1.20	4.50	1.35	.50	.20	.50	.20	— .10
29	.70	.....	1.30	6.40	2.00	6.00	1.40	.60	.20	.50	.20	.00
30	.80	.....	1.50	4.60	2.00	4.80	1.55	.60	.10	.50	—.70	.00
31	.80	.....	1.85	.....	2.00	.....	1.50	.60	.....	.60	.....	— .10

GRANITE STATION ON ARKANSAS RIVER.

This station is located at the wagon bridge 250 feet from the railroad station at Granite, Colorado. The gage is a vertical 2 by 6 inch plank spiked to the upper end of the center pier of the bridge and graduated to tenths of a foot. The banks are low and liable to overflow; the bed is rocky and the current swift. This station was reestablished April 17, 1897, by Cyrus C. Babb, the records of daily gage heights being kept by the Denver and Rio Grande Railroad Company. The observer is H. D. Marquis. The following is a list of measurements of discharge made in 1897 by F. Cogswell:

April 17, gage height, 3.20 feet; discharge, 120 second-fee
May 8, gage height, 4.20 feet; discharge, 940 second-feet.
May 18, gage height, 4.90 feet; discharge, 1,326 second-feet.
June 29, gage height, 4.60 feet; discharge, 1,151 second-feet.
July 27, gage height, 3.75 feet; discharge, 415 second-feet.
August 31, gage height, 3.20 feet; discharge, 206 second-feet.
September 27, gage height, 3.10 feet; discharge, 203 second-feet.
November 6, gage height, 3.00 feet; discharge, 153 second-feet.

Daily gage height, in feet, of Arkansas River at Granite, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1....	3.35	6.00	4.50	3.65	3.35	3.00	17.....	4.75	5.25	4.00	3.45	3.00	3.00
2....	3.60	6.00	4.35	3.65	3.35	3.00	18.....	4.90	5.00	3.85	3.40	3.15	3.00
3....	3.65	6.00	4.35	3.80	3.35	3.00	19.....	4.90	4.85	3.85	3.35	3.10	3.00
4....	3.55	5.75	4.30	3.70	3.50	3.00	20.....	5.00	4.85	3.85	3.35	3.00	3.00
5....	3.75	5.00	4.25	3.65	3.50	3.00	21.....	5.10	5.00	3.90	3.35	3.00	3.00
6....	3.85	5.00	4.10	3.65	3.40	3.00	22.....	4.90	5.10	3.85	3.35	3.00	3.00
7....	4.05	4.40	4.35	3.75	3.25	3.00	23.....	5.10	5.00	3.90	3.30	3.00	3.00
8....	4.05	4.50	4.35	3.75	3.25	3.00	24.....	5.60	4.90	3.80	3.25	3.00	3.00
9....	4.35	4.50	4.50	3.80	3.25	3.00	25.....	5.60	4.65	3.80	3.25	3.00	3.00
10....	4.25	4.75	4.60	3.65	3.25	3.00	26.....	5.60	4.85	3.75	3.25	3.00	3.00
11....	4.30	5.35	4.40	3.60	3.00	3.00	27.....	5.60	4.90	3.75	3.25	3.00	.....
12....	4.10	5.60	4.35	3.60	3.00	3.00	28.....	5.40	4.75	3.75	3.25	3.00	.....
13....	4.00	5.60	4.15	3.65	3.00	3.00	29.....	5.65	4.60	3.65	3.25	3.00	.....
14....	4.00	6.00	4.00	3.65	3.00	3.00	30.....	5.75	4.45	3.65	3.20	3.00	.....
15....	4.10	5.75	4.05	3.50	3.00	3.00	31.....	6.00	.....	3.65	3.15	.....	.....
16....	4.60	6.15	4.00	3.50	3.00	3.00							

SALIDA STATION ON ARKANSAS RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 224, is located just back of the railroad yards, at a suspension bridge, at Salida, Colorado. The gage consists of a vertical 4 by 6 inch timber, with a 2 by 6 inch scale, bolted to the abutment of the bridge on the left-hand side of the river, and is marked to tenths of a foot. The banks are high and do not overflow; the current is swift; the bed of the stream consists of sand, gravel, and bowlders, but is not subject to any great changes, and is a most desirable station to be maintained. Stream measurements are made from the lower side of the footbridge. River-height observations are maintained by the Denver and Rio Grande Railroad Company. The observer is F. G. Dew. The following discharge measurements were made in 1897 by F. Cogswell:

April 17, gage height, 0.69 foot; discharge, 219 second-feet.
April 27, gage height, 1.55 feet; discharge, 709 second-feet.
May 8, gage height, 2.20 feet; discharge, 1,178 second-feet.
May 30, gage height, 4.05 feet; discharge, 2,821 second-feet.
June 29, gage height, 2.50 feet; discharge, 1,492 second-feet.
July 27, gage height, 1.35 feet; discharge, 606 second-feet.
August 31, gage height, 0.85 foot; discharge, 371 second-feet.
September 27, gage height, 1.00 foot; discharge, 405 second-feet.
November 6, gage height, 0.90 foot; discharge, 378 second-feet.

Daily gage height, in feet, of Arkansas River at Salida, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1....	1.20	4.10	2.30	1.30	1.00	0.65	17.....	2.75	3.00	1.90	1.20	0.90	0.65
2....	1.45	3.60	2.35	1.25	1.00	.65	18.....	3.10	3.00	1.85	1.15	.90	.65
3....	1.75	3.10	2.45	1.25	1.00	.65	19.....	3.00	2.90	2.00	1.10	.90	.65
4....	1.60	2.90	2.35	1.35	1.00	.65	20.....	3.00	2.75	1.90	1.10	1.00	.65
5....	1.60	2.40	2.00	1.45	1.00	.65	21.....	3.00	3.00	1.90	1.00	1.00	.65
6....	1.80	2.45	2.00	1.45	1.05	.65	22.....	2.85	3.00	1.65	1.10	1.00	.65
7....	1.95	2.25	2.00	1.40	1.00	.65	23.....	3.00	3.00	1.50	1.05	1.00	.65
8....	2.25	2.10	2.00	1.45	1.00	.65	24.....	3.50	3.00	1.50	1.00	1.00	.65
9....	2.25	2.35	2.45	1.55	1.00	.65	25.....	3.50	2.80	1.45	1.00	1.00	.65
10....	2.30	2.75	2.45	1.50	1.00	.65	26.....	3.40	2.75	1.40	1.00	1.00	.85
11....	2.30	2.80	2.20	1.40	1.00	.65	27.....	3.60	2.90	1.40	1.00	1.00	.....
12....	2.50	2.90	2.05	1.40	1.00	.65	28.....	3.45	2.55	1.40	1.00	1.00	.....
13....	2.30	3.50	2.00	1.35	1.00	.65	29.....	3.50	2.40	1.25	1.00	1.00	.....
14....	2.35	3.20	1.90	1.35	1.00	.65	30.....	4.00	2.35	1.25	1.00	1.00	.....
15....	2.35	3.35	1.95	1.35	1.00	.65	31.....	4.15	.....	1.25	1.00	.....	.....
16....	2.70	3.65	1.90	1.25	1.00	.65							

CANYON STATION ON ARKANSAS RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 225, is located at the Hot Springs Hotel, 1½ miles west of Canyon, Colorado, about 500 yards below the mouth of Grape Creek. The gage rod is placed on the left bank of the river just below the suspension footbridge, and consists of an inclined 4 by 4 inch by 16-foot timber bolted to a small juniper tree, and to posts set in the ground. A vertical rod is also fastened to the juniper tree for extreme high water. Both banks are high and not liable to overflow. The current is swift, and the cross section is not subject to any notable changes, except at extreme high-and-low-water stages. The observer is Dr. J. L. Prentiss. The following discharge measurements were made in 1897 by F. Cogswell:

April 16, gage height, 2.20 feet; discharge, 260 second-feet.
May 7, gage height, 3.10 feet; discharge, 827 second-feet.
May 26, gage height, 4.95 feet; discharge, 2,712 second-feet.
June 16, gage height, 5.25 feet; discharge, 3,071 second-feet.
July 14, gage height, 3.60 feet; discharge, 1,140 second-feet.
August 11, gage height, 3.05 feet; discharge, 714 second-feet.
November 5, gage height, 2.98 feet; discharge, 540 second-feet.

Daily gage height, in feet, of Arkansas River at Canyon City, Colorado, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	2.50	2.80	5.40	3.95	2.80	2.40	2.60	3.00	.....
2	2.60	.....	.....	2.50	2.90	5.40	3.85	2.80	2.40	2.50	3.00	.....
3	.....	.....	.....	2.50	3.10	5.40	3.75	2.85	2.40	2.50	3.00	.....
4	.....	.....	.....	2.40	3.05	5.55	3.95	3.60	2.40	2.50	2.90	2.50
5	.....	.....	.....	2.40	3.00	4.85	3.75	3.20	2.40	2.50	2.95	.....
6	.....	2.50	2.50	2.30	3.15	4.25	3.60	3.00	2.40	2.50	2.95	.....
7	.....	.....	.....	2.30	3.10	4.35	3.50	3.10	2.40	2.50	2.95	.....
8	.....	.....	.....	2.20	3.50	4.50	3.50	3.40	2.40	2.60	2.90	.....
9	2.50	.....	.....	2.20	3.60	4.60	4.17	3.30	2.45	2.70	2.90	.....
10	.....	.....	.....	2.10	3.70	4.70	3.90	3.20	2.45	2.70	2.90	.....
11	.....	.....	.....	2.15	3.65	4.65	4.00	3.10	2.45	2.70	2.90	2.60
12	.....	.....	.....	2.20	3.60	4.95	3.85	3.10	2.50	2.70	2.95	.....
13	.....	2.40	2.60	2.20	3.70	5.35	3.70	3.00	2.50	2.60	2.95	.....
14	.....	.....	.....	2.20	3.80	5.25	3.60	2.90	2.60	2.65	3.00	.....
15	.....	.....	.....	2.10	4.10	5.15	3.75	2.90	2.60	2.70	2.95	.....
16	2.30	.....	.....	2.20	4.30	5.30	3.55	2.80	2.60	2.80	2.85	.....
17	.....	.....	.....	2.20	4.50	5.15	3.50	2.80	2.60	2.80	2.85	.....
18	.....	.....	.....	2.35	4.30	4.65	3.50	2.70	2.55	2.80	2.85	2.60
19	.....	.....	.....	2.40	4.30	4.50	3.70	2.70	2.55	2.85	2.85	.....
20	.....	2.50	2.50	2.50	4.25	4.50	3.60	2.60	2.50	2.85	2.85	.....
21	.....	.....	.....	2.55	4.30	4.50	3.50	2.60	2.50	2.80	.....	.....
22	.....	.....	.....	2.45	4.35	4.50	3.40	2.60	2.50	2.80	2.85	.....
23	2.40	.....	.....	2.25	4.40	4.50	3.30	2.70	2.50	2.80	2.85	.....
24	.....	2.70	.....	2.20	4.75	4.45	3.20	2.55	2.50	2.80	2.75	.....
25	.....	2.70	.....	2.20	5.00	4.45	3.20	2.50	2.50	2.80	2.70	2.50
26	.....	.....	.....	2.30	5.05	4.50	3.10	2.50	2.50	2.80	2.70	.....
27	.....	2.50	2.60	2.55	5.00	4.35	3.00	2.50	2.50	2.80	2.70	.....
28	.....	.....	2.60	2.55	5.05	4.25	2.90	2.50	2.50	2.90	2.65	.....
29	.....	.....	2.70	2.85	5.10	4.05	2.90	2.50	2.50	3.00	2.60	.....
30	2.50	.....	2.60	2.75	5.35	4.00	2.85	2.50	2.50	3.00	2.50	.....
31	.....	.....	2.50	.....	5.45	.....	2.80	2.40	.....	.....	.....	.....

PUEBLO STATION ON ARKANSAS RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 227, is located at the city of Pueblo, Colorado, 2 miles above the mouth of Fountain Creek. There are two gage rods. The main one, at Santa Fe avenue bridge, consists of a vertical 6 by 6 inch timber, bolted to the abutment of the Denver and Rio Grande Railroad bridge on the left-hand side of the river, marked to tenths of a foot. There is also a short vertical rod for extreme low water spiked to a pile about 20 feet out in the stream, reading same as the main gage. The 12-foot mark of this gage is opposite the top of the large capstone. The rod at Victoria avenue bridge consists of inclined 4 by 4 inch timbers fastened to posts set in right bank of stream, and was placed for the purpose of noting the change in the slope of the water surface. Stream measurements are made from lower side of the Main street bridge. The river is confined by the city levees, and the bed is sandy and constantly changing. The observer is R. L. Holden. The following is a list of discharge measurements made in 1897 by F. Cogswell and others:

April 16, gage height, 0.20 foot; discharge, 216 second-feet.
May 6, gage height, 1.00 foot; discharge, 799 second-feet.
May 21, gage height, 2.00 feet; discharge, 1,856 second-feet.
June 18, gage height, 2.55 feet; discharge, 2,219 second-feet.
July 16, gage height, 1.15 feet; discharge, 981 second-feet.
August 10, gage height, 0.95 foot; discharge, 805 second-feet.
September 8, gage height, 0.10 foot; discharge, 184 second-feet.
September 28, gage height, 0.45 foot; discharge, 394 second-feet.
November 4, gage height, 0.75 foot; discharge, 601 second-feet.

Daily gage height, in feet, of Arkansas River at Pueblo, Colorado, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.30	0.65	0.30	0.20	0.70	3.30	1.45	0.55	0.20	0.20	0.70	0.45
2	.30	.40	.30	.00	.75	3.50	1.55	.60	.20	.20	.70	.50
3	.30	.40	.30	.15	1.00	3.05	1.65	.80	.10	.20	.70	.40
4	.35	.45	.25	.20	1.05	2.50	1.45	.65	.10	.25	.70	.45
5	.35	.35	.15	.15	.95	2.15	1.45	.95	.10	.30	.70	.40
6	.25	.35	.10	.05	.95	2.05	1.45	.60	.10	.30	.70	.40
7	.35	.45	.10	.00	1.05	1.90	1.65	1.20	.10	.35	.60	.45
8	.45	.40	.05	.10	1.30	1.75	1.10	1.05	.10	.40	.60	.50
9	.25	.35	.00	.00	1.40	1.70	2.10	1.45	.05	.35	.60	.50
10	.45	.40	.05	.05	1.45	2.00	2.00	1.00	.00	.55	.50	.50
11	.45	.45	.00	.00	1.45	2.45	1.85	.95	.10	.35	.55	.45
12	.50	.40	.00	.05	1.45	2.85	1.60	.90	.10	.45	.70	.40
13	.45	.45	.05	.10	1.35	2.90	1.35	.75	.25	.35	.70	.40
14	.35	.30	.05	.00	1.40	3.20	1.20	.55	.30	.35	.70	.50
15	.35	.20	.05	.00	1.45	3.00	2.10	.40	.50	.35	.70	.45
16	.30	.15	.15	.00	1.60	2.95	1.25	.40	.40	.45	.60	.40
17	.35	.40	.00	.15	1.90	3.05	1.15	.30	.35	.60	.50	.50
18	.25	.40	.25	.20	1.90	2.55	1.25	.30	.35	.60	.40	.45
19	.30	.30	.20	.30	2.20	2.30	1.45	.30	.40	.65	.50	.30
20	.30	.40	.20	.30	2.15	2.15	1.35	.30	.30	.70	.45	.30
21	.35	.35	.15	.35	2.00	2.30	1.15	.20	.30	.65	.40	.30
22	.30	.35	.15	.35	1.90	2.20	1.00	.20	.35	.60	.55	.30
23	.35	.40	.10	.30	1.85	2.15	.85	.20	.30	.55	.50	.20
24	.30	.25	.05	.10	2.15	2.00	.85	.40	.30	.55	.50	.20
25	.25	.25	.00	.25	2.85	1.95	.75	.35	.30	.50	.50	.20
26	.20	.25	.10	.30	2.85	1.85	.75	.25	.35	.65	.50	.20
27	.30	.25	.20	.30	2.75	2.00	.85	.20	.40	.60	.50	.30
28	.25	.20	.25	.35	3.05	1.90	.85	.10	.40	.50	.40	.40
29	.35	.....	.40	.65	2.80	1.65	.70	.20	.40	.60	.40	.45
30	.65	.....	.40	.75	3.15	1.50	.55	.20	.35	.65	.45	.40
31	.50	.....	.30	.....	3.30	.....	.55	.20	.....	.65	.....	.30

NEPESTA STATION ON ARKANSAS RIVER.

This station is located 1,000 feet north of Nepesta, Colorado, at a wagon bridge, 200 feet below Atchison, Topeka and Santa Fe Railroad bridge, and was established September 8, 1897. The gage consists of a vertical 2 by 6 inch by 12 foot timber marked in tenths, securely wired to upstream side of upstream cylinder of bridge on left side of river and marked with 1 by 6 inch scale on face and 1 by 3 inch scale on side. The initial point for soundings is on the left bank, which is low and liable to overflow. The right bank is high and riprapped above railroad bridge. The channel above and below the station is straight for 300 or 400 feet; the bed is sandy and shifting. The observer is G. J. Boyd, a storekeeper, who lives 1,000 feet from the gage. The following discharge measurements were made by Porter J. Preston in 1897:

September 8, gage height, 2.00 feet; discharge, 168 second-feet.
September 30, gage height, 2.34 feet; discharge, 281 second-feet.

Daily gage height, in feet, of Arkansas River at Nepesta, Colorado, for 1897.

Day.	Sept.	Oct.	Day.	Sept.	Oct.	Day.	Sept.	Oct.	Day.	Sept.	Oct.
1	.....	2.20	9	.....	2.15	17	.....	.....	25	2.00	.....
2	.....	2.10	10	.....	2.15	18	.....	.....	26	2.00	.....
3	.....	2.00	11	.....	2.20	19	1.90	.....	27	2.00	.....
4	.....	2.10	12	.....	2.35	20	1.50	.....	28	2.10	.....
5	.....	2.00	13	.....	1.75	21	1.80	.....	29	2.00	.....
6	.....	2.20	14	.....	2.00	22	2.10	.....	30	2.00	.....
7	.....	2.10	15	.....	2.10	23	2.00	.....	31	.....	.....
8	.....	2.05	16	.....	2.00	24	2.10	.....			

ROCKY FORD STATION ON ARKANSAS RIVER.

This station is located 2 miles northeast of Rocky Ford, Colorado, and was established May 3, 1897. The gage consists of a vertical 1 by 3 inch timber notched in tenths and securely nailed to pile protection to abutment of wagon bridge, left side of stream, upper side of bridge. The initial point of soundings is on the left bank at water's edge. Both banks are high and liable to overflow only at very high water. The channel is straight for about 300 feet above and below the station. The bed is sandy and shifting. The observer, S. W. Cressy, whose occupation is water commissioner, lives 2 miles distant from the gage. The following discharge measurement was made by Porter J. Preston in 1897:

September 29, gage height, 0.37 foot; discharge, 140 second-feet.

Daily gage height, in feet, of Arkansas River at Rocky Ford, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.70	0.72	0.65	0.45	0.40	0.92	0.38
2	.....	2.50	.55	.65	.50	.38	1.02	.40
3	1.00	2.82	.80	.68	.42	.30	1.10	(a)
4	1.10	2.52	1.42	.69	.32	.32	1.10	.....
5	1.28	2.08	1.50	1.94	.25	.25	1.08	.....
6	1.25	2.40	1.50	1.60	.35	.32	1.10	.....
7	.90	1.98	1.25	1.28	.35	.35	.88	.....
8	.50	1.80	1.10	2.05	.30	.38	.68	.....
9	1.02	1.65	1.00	1.60	.30	.40	.60	.....
10	1.18	1.65	1.52	1.90	.18	.50	.60	.....
11	1.23	1.72	1.60	1.02	.30	.78	.58	.....
12	1.15	2.10	1.26	.60	.30	.65	.50	.....
13	1.37	2.40	1.26	1.28	.35	.45	.65	.....
14	1.42	2.40	1.17	.75	.35	.40	.48	.....
15	1.42	2.48	1.33	.82	.20	.60	.60	.....
16	1.32	2.22	1.41	3.10	.45	.72	.60	.....
17	1.40	2.20	.82	2.10	.66	.80	.48	.....
18	1.50	2.15	1.38	.95	.70	.80	.45	.....
19	1.60	2.00	2.05	1.15	.45	.82	.42	.....
20	1.55	1.75	1.80	.95	.38	.88	.....	.....
21	1.60	1.62	1.02	.80	.25	.90	.50	.....
22	1.45	1.50	.62	.60	.15	.88	.50	.....
23	1.48	1.50	.50	.55	.20	.85	.45	.....
24	1.50	1.25	.40	.70	.20	.84	.50	.....
25	1.40	1.17	.35	.58	.22	.85	.50	.....
26	1.80	1.24	.35	.48	.30	.98	.50	.....
27	1.85	1.17	.61	.38	.35	1.00	.53	.....
28	2.90	1.82	.65	.30	.35	.98	.50	.....
29	2.00	1.75	.85	.22	.38	.92	.51	.....
30	2.05	1.22	.85	.20	.40	.80	.35	.....
31	2.38	.....	.68	.32	.....	.80	.....	.....

a River frozen.

TRINIDAD STATION ON PURGATOIRE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 231, is located at the Las Animas street bridge in the city of Trinidad, Colorado. The gage consists of a vertical 2 by 6 inch plank, and is fastened with iron bands to the downstream side of a cylindrical bridge pier, on the right side of the river. The banks are high and not liable to overflow, the bed is of gravel and small stones, and the water moves with fair velocity. Stream measurements are made from the lower side of the bridge during high water, and at low stages by wading some 400 feet below the gage. The observer is J. N. Turner, water commissioner. The following measurements of discharge were made in 1897 by F. Cogswell:

May 22, gage height, 4.25 feet; discharge, 677 second-feet.
June 17, gage height, 4.10 feet; discharge, 386 second-feet.
July 15, gage height, 3.90 feet; discharge, 189 second-feet.
September 23, gage height, 3.60 feet; discharge, 49 second-feet.
November 13, gage height, 3.55 feet; discharge, 46 second-feet.

Daily gage height, in feet, of Purgatoire River at Trinidad, Colorado, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	3.75	4.05	4.20	4.15	3.50	3.50	3.60	3.60
2	3.70	4.15	4.25	4.05	3.45	3.50	3.60	3.60
3	3.75	4.05	4.30	4.00	3.65	3.50	3.60	3.55
4	3.75	4.30	4.20	3.90	3.60	3.50	3.60	3.55
5	3.75	4.30	4.05	3.90	3.55	3.55	3.60	3.50
6	3.65	4.35	4.00	3.85	4.00	3.60	3.60	3.50
7	3.75	4.30	4.00	3.80	3.85	3.55	3.60	3.60
8	3.75	4.30	4.00	3.80	4.80	3.50	3.60	3.60
9	3.80	4.40	4.00	4.65	4.25	3.60	3.65	3.60
10	3.85	4.30	4.00	4.20	4.10	3.95	3.60	3.60
11	3.75	4.25	4.00	4.10	3.95	3.95	3.60	3.60
12	3.80	4.20	4.05	4.00	4.00	3.90	3.60	3.60
13	3.90	4.30	4.10	3.95	3.90	4.10	3.60	3.60
14	3.90	4.30	4.15	3.90	3.90	3.90	3.60	3.60
15	3.85	4.30	4.10	3.90	4.70	3.90	3.60	3.50
16	3.75	4.15	4.10	3.95	4.00	4.05	3.60	3.55
17	3.80	4.20	4.10	4.00	4.00	3.85	3.75	3.55
18	3.75	4.20	4.05	4.00	4.00	3.75	3.65	3.50
19	3.90	4.35	4.00	3.95	3.90	3.60	3.60	3.50
20	3.90	4.55	4.00	3.90	4.00	3.55	3.60	3.50
21	4.00	4.40	3.90	3.90	3.90	3.60	3.60	3.50
22	3.90	4.22	3.90	3.80	4.00	3.50	3.60	3.50
23	3.85	4.20	3.90	3.80	4.00	3.60	3.60	3.50
24	3.95	4.20	3.90	3.80	3.90	3.60	3.60	3.60
25	4.00	4.20	3.90	3.80	3.60	3.50	3.70	3.60
26	3.95	4.30	4.60	3.80	3.45	3.60	3.70	3.60
27	3.90	4.35	4.25	3.80	3.40	3.60	3.65	3.50
28	4.00	4.30	4.05	3.80	3.30	3.60	3.65	3.50
29	4.00	4.25	4.00	3.75	3.35	3.60	3.65	3.50
30	4.05	4.30	4.20	3.55	3.40	3.60	3.60	3.50
31	.....	4.30	.....	3.50	3.40	.....	3.60	.....

HUTCHINSON STATION ON ARKANSAS RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 232, is located at the wagon bridge at the south end of Main street, Hutchinson, Kansas. The observer is Daniel Lauer, who lives about 100 yards from the station. The gage consists of an oak timber painted white, graduated in feet and tenths and spiked to an oak pile a few feet above the bridge, driven as a protection to the bridge pier from ice and drift. There are two bench marks: One is the upper cross piece of the pier guard, having an elevation of 8.35 feet above zero; the second is the top of the iron doorsill, next to the river, of the first brick building. Its elevation is 8.12 feet above zero of the gage. Measurements are made from the bridge, and at low water may be made by wading. The channel is generally straight for some distance, both above and below, and is sandy and very shifting. At very low stages the water is in several channels and crooked. The following discharge measurements were made in 1897 by W. G. Russell:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Feb. 25	2.30	471	May 18	2.00	202	Aug. 3	1.15	6
Mar. 25	1.75	158	June 3	1.60	60	Aug. 20	2.20	275
Apr. 14	2.00	221	June 29	2.10	284	Sept. 29	1.10	4
Apr. 22	1.70	122	July 14	1.30	15			
May 7	1.95	170	July 27	1.10	4			

Daily gage height, in feet, of Arkansas River at Hutchinson, Kansas, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.60	1.80	2.20	1.70	2.15	1.60	1.85	1.35	2.00	1.10	1.30	(a)
2	1.60	1.80	2.15	1.70	2.10	1.60	1.75	1.15	1.95	1.10	1.30	(a)
3	1.80	1.80	2.30	1.80	2.05	1.55	1.70	1.05	1.90	1.10	1.30	(a)
4	1.80	2.20	2.30	1.80	2.00	1.55	1.95	1.00	1.80	1.10	1.30	(a)
5	1.80	2.20	2.25	1.90	2.00	1.60	1.75	1.00	1.75	1.10	1.30	1.65
6	1.80	2.20	2.20	2.05	2.00	1.60	1.55	1.10	1.65	1.10	1.30	1.70
7	1.80	1.70	2.20	2.10	2.00	1.60	1.55	1.10	1.55	1.10	1.30	1.60
8	1.80	1.80	2.10	2.20	1.95	1.60	1.45	1.10	1.50	1.10	1.30	1.50
9	1.80	1.80	2.10	2.20	1.90	1.60	1.40	1.10	1.50	1.10	1.30	1.50
10	1.80	1.90	2.10	2.20	2.10	1.55	1.65	1.05	1.45	1.10	1.30	1.50
11	1.80	2.45	2.00	2.15	2.30	1.90	1.50	1.00	1.40	1.10	1.30	1.50
12	1.80	2.35	1.90	2.10	2.40	2.10	1.50	1.00	1.35	1.05	1.30	1.50
13	1.70	2.25	1.90	2.05	2.35	2.20	1.40	1.00	1.30	1.00	1.30	1.45
14	1.70	2.80	2.10	1.95	2.30	2.20	1.35	1.45	1.30	1.00	1.20	1.40
15	1.70	2.70	1.85	1.90	2.15	2.20	1.30	1.30	1.30	1.00	1.20	1.40
16	1.70	1.65	1.80	1.85	2.10	2.20	1.30	1.15	1.75	1.05	1.20	1.40
17	1.70	1.60	1.80	1.80	2.05	2.20	1.30	2.05	1.65	1.20	1.20	1.40
18	1.70	1.60	1.80	1.80	2.00	2.20	1.30	2.25	1.55	1.45	1.20	1.40
19	1.80	1.60	1.80	1.80	1.90	2.15	1.30	2.30	1.50	1.40	1.20	1.40
20	1.90	2.05	1.80	1.80	1.90	2.20	1.25	2.20	1.45	1.40	1.20	1.40
21	1.90	2.50	1.80	1.70	1.90	2.20	1.20	2.15	1.40	1.40	1.20	1.40
22	1.90	2.50	1.80	1.70	1.90	2.20	1.10	2.00	1.35	1.40	1.20	1.40
23	1.90	2.45	1.80	1.70	1.85	2.30	1.10	2.20	1.30	1.30	1.20	1.40
24	1.90	2.35	1.80	1.85	1.80	2.30	1.10	2.65	1.30	1.30	1.30	1.40
25	1.90	2.30	1.75	2.10	1.75	2.30	1.20	2.95	1.25	1.35	1.35	1.40
26	1.80	2.30	1.70	2.15	1.70	2.30	1.20	2.75	1.20	1.40	1.40	1.40
27	1.60	2.20	1.70	2.20	1.70	2.25	1.30	2.55	1.20	1.30	1.40	1.40
28	1.60	3.85	1.70	2.20	1.70	2.15	1.35	2.30	1.20	1.30	1.30	1.40
29	1.60	.....	1.70	2.20	1.65	2.10	1.70	2.20	1.10	1.30	1.30	1.40
30	1.60	.....	1.70	2.20	1.60	2.05	1.60	2.20	1.10	1.30	1.30	1.40
31	1.80	.....	1.70	.....	1.60	.....	1.45	2.10	.....	1.30	.....	1.40

a Frozen.

LIBERTY STATION ON VERDIGRIS RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 235, is located at a wagon bridge, about 250 feet below McTaggart's milldam, about 3 miles southwest of the town of Liberty, Kansas. The gage is in two parts—a vertical board marked to feet and tenths fastened to the flume, which serves to give ordinary heights, and horizontal marks one-half foot apart on the corner of wheelhouse. The zero of gage is 12.46 feet below the heads of three large nails in flume. Bench mark 2 is the head of a spike in root of cottonwood tree 4.75 feet in circumference and 40 feet south of gage. The spike has a circle cut around it, with letters U. S. above. Its elevation is 10.98 feet above datum. The bed is rock and gravel, and subject to very little change. September 11, 1897, a secondary gage was placed about 7 miles above gage No. 1. It is located at the Independence waterworks, and is to be read hourly when the river is in flood. The zeros of the two gages are referred to the same datum. The observer is A. C. McTaggart. The following discharge measurements were made in 1897 by E. C. Murphy:

April 2, gage height, 6.55 feet; discharge, 2,558 second-feet.
April 3, gage height, 5.87 feet; discharge, 2,003 second-feet.
April 30, gage height, 17.00 feet; discharge, 10,367 second-feet.
May 1, gage height, 7.38 feet; discharge, 3,384 second-feet.
June 29, gage height, 2.35 feet; discharge, 70 second-feet.
July 20, gage height, 3.00 feet; discharge, 312 second-feet.
September 8, gage height, 1.95 feet; discharge, 14 second-feet.

Daily gage height, in feet, of Verdigris River at Liberty, Kansas, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.60	3.60	10.15	7.20	2.90	2.40	2.20	2.00	2.00	1.70	1.60
2	3.80	.....	3.60	7.05	5.80	2.90	2.40	2.20	2.00	.....	.....	.....
3	.....	3.40	3.80	5.70	5.25	3.10	2.40	2.20	2.00	.....	1.60	1.60
4	4.00	.....	5.00	5.05	4.95	2.90	2.40	2.20	2.00	1.90	.....	.....
5	.....	9.80	20.00	4.75	4.65	2.90	2.45	2.20	2.00	.....	1.60	.....
6	3.80	.....	13.75	4.55	4.45	2.90	9.45	2.20	2.00	1.80	.....	1.70
7	.....	.....	7.50	4.35	4.35	3.00	6.90	2.20	2.00	.....	.....	.....
8	.....	6.00	6.00	4.30	4.15	3.00	5.00	2.10	2.00	1.80	1.60	1.70
9	3.30	.....	7.15	4.30	4.10	8.25	3.70	2.10	2.00	.....	.....	.....
10	.....	5.60	6.90	4.55	4.10	6.65	2.95	2.10	2.00	.....	1.60	1.70
11	3.20	.....	5.80	5.00	6.05	4.75	2.75	2.10	2.00	1.80	.....	.....
12	.....	7.20	4.95	4.70	13.25	4.10	2.60	2.10	.....	.....	1.60	.....
13	4.20	.....	4.80	4.30	6.85	3.60	2.50	2.10	2.00	1.80	.....	1.70
14	.....	.....	4.35	4.15	5.10	3.40	2.50	2.10	.....	.....	.....	.....
15	.....	5.00	4.25	4.00	4.80	3.30	2.45	2.10	2.00	1.80	1.60	1.90
16	4.30	.....	4.10	3.85	4.50	3.30	2.40	2.10	.....	.....	.....	.....
17	.....	5.30	5.05	3.70	4.30	3.20	2.40	2.10	.....	.....	1.60	1.90
18	5.10	.....	5.80	3.60	4.15	3.10	2.40	2.10	2.00	1.70	.....	.....
19	.....	4.60	5.40	3.60	3.95	3.00	2.00	2.10	.....	.....	1.60	.....
20	5.30	.....	5.55	3.60	3.75	3.10	2.95	2.10	2.00	1.70	.....	1.90
21	.....	.....	5.70	3.60	3.55	3.35	3.05	2.10	.....	.....	.....	.....
22	5.30	4.40	5.10	3.40	3.35	3.10	2.80	2.00	2.00	1.70	1.60	2.20
23	.....	.....	4.60	3.40	4.05	2.80	2.80	2.00	.....	.....	.....	.....
24	.....	4.00	4.20	3.40	3.95	2.70	2.70	2.00	.....	.....	1.60	2.20
25	4.70	.....	4.00	6.85	3.70	2.60	2.55	2.00	2.00	1.70	.....	.....
26	.....	4.00	3.95	6.70	3.55	2.50	2.35	2.00	.....	.....	1.60	.....
27	4.10	.....	3.80	4.85	3.20	2.50	2.20	2.00	2.00	1.70	.....	1.75
28	.....	.....	3.80	18.75	3.10	2.40	2.20	2.00	.....	.....	.....	.....
29	3.80	.....	3.80	28.20	3.00	2.40	2.20	2.00	2.00	1.70	1.60	1.90
20	.....	.....	6.50	21.50	3.00	2.30	2.20	2.00	.....	.....	.....	.....
31	.....	.....	9.30	.....	3.00	.....	2.20	2.00	.....	.....	.....	1.90

IOLA STATION ON NEOSHO RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 238, is located at a highway bridge 1 mile west of the city of Iola, Kansas. The gage is in two parts—one part, a vertical board marked to feet and tenths and fastened to flume, serves to give ordinary heights; the other is a smooth stone wall near by, having horizontal lines on it one-half foot apart, for use when the water is high. The zero is 13.30 feet below the heads of three large nails driven into crosspiece of flume. The observer is Elias Bruner. The following is a list of discharge measurements made by E. C. Murphy in 1897:

March 19, gage height, 3.15 feet; discharge, 566 second-feet.
April 1, gage height, 4.60 feet; discharge, 2,049 second-feet.
April 2, gage height, 4.35 feet; discharge, 1,752 second-feet.
May 1, gage height, 3.28 feet; discharge, 544 second-feet.
June 28, gage height, 4.75 feet; discharge, 2,226 second-feet.
December 1, gage height, 1.80 feet; discharge, 1 second-foot.

Daily gage height, in feet, of Neosho River at Iola, Kansas, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.20	3.20	2.95	4.75	3.30	2.40	2.25	2.00	2.05	1.80	1.80	1.80
2	2.30	3.50	3.05	4.20	3.30	2.40	2.20	2.10	2.00	1.80	1.80	1.80
3	2.40	3.90	3.00	4.10	3.30	2.40	2.20	2.10	2.00	1.80	1.80	1.80
4	2.50	5.90	3.10	3.85	3.20	2.45	2.25	2.10	2.00	1.80	1.80	1.80
5	2.60	4.70	6.35	3.65	3.20	2.50	2.35	2.10	1.90	1.80	1.80	1.80
6	2.60	3.20	5.05	3.45	3.15	2.50	2.30	2.10	1.90	1.80	1.80	1.80
7	2.60	3.30	4.00	3.40	3.10	2.50	2.20	2.10	1.80	1.80	1.80	1.80
8	2.70	3.15	3.55	3.60	3.10	2.45	2.65	2.00	1.80	1.80	1.80	1.80
9	2.90	3.45	3.45	3.90	3.10	2.40	2.70	2.10	1.80	1.80	1.80	1.80
10	2.90	3.75	3.25	4.00	3.00	2.40	2.90	2.10	1.80	1.80	1.80	1.80
11	2.95	4.25	3.05	4.00	3.00	3.60	2.95	2.10	1.80	1.80	1.80	1.80
12	3.10	5.15	2.95	4.00	3.00	3.55	2.85	2.10	1.80	1.80	1.80	1.80
13	3.15	4.85	2.90	3.90	3.00	3.25	2.75	2.10	1.80	1.80	1.80	1.80
14	3.20	4.80	2.90	3.80	2.90	3.15	2.65	2.10	1.80	1.80	1.80	1.80
15	3.20	5.85	2.80	3.65	2.90	2.85	2.50	2.00	1.80	1.80	1.80	1.80
16	3.15	5.30	2.85	3.40	2.90	2.75	2.40	2.10	1.80	1.80	1.80	1.80
17	3.00	4.80	2.90	3.20	2.80	2.55	2.30	2.10	1.80	1.80	1.80	1.80
18	3.20	5.40	2.90	3.10	2.80	2.35	2.30	2.10	1.80	1.80	1.80	1.80
19	3.20	5.85	3.05	3.10	2.70	2.25	2.25	2.15	1.80	1.80	1.80	1.80
20	3.30	5.20	4.85	3.10	2.70	2.30	2.25	2.15	1.80	1.80	1.80	1.80
21	3.40	4.65	3.85	3.00	2.60	2.25	2.20	2.15	1.80	1.80	1.80	1.80
22	3.50	4.30	3.50	3.00	2.60	2.20	2.20	2.10	1.80	1.80	1.80	1.80
23	3.60	3.85	3.05	3.00	2.50	2.20	2.20	2.10	1.80	1.80	1.80	1.80
24	3.60	3.25	3.25	2.90	2.50	2.10	2.20	2.10	1.80	1.80	1.80	1.80
25	3.50	2.70	3.20	2.90	2.50	2.10	2.15	2.10	1.80	1.70	1.80	1.80
26	3.50	3.30	3.10	3.10	2.50	2.50	2.15	2.10	1.80	1.70	1.80	1.80
27	3.40	3.00	3.00	3.10	2.40	3.85	2.15	2.10	1.80	1.70	1.80	1.80
28	3.35	2.90	3.00	3.45	2.40	3.85	2.15	2.10	1.80	1.70	1.80	1.80
29	3.30	.....	3.00	3.55	2.40	4.10	2.15	2.00	1.80	1.70	1.80	1.80
30	3.30	.....	4.80	3.45	2.40	2.75	2.15	2.05	1.80	1.70	1.80	1.80
31	3.30	.....	5.35	.....	2.40	.....	2.15	2.05	.....	1.80	.....	1.80

DEL NORTE STATION ON RIO GRANDE.

This station, described in the Eighteenth Annual Report, Part IV, page 246, is located about two miles above the town of Del Norte, Colorado. The gage consists of an inclined 2 by 6 inch plank, fastened to posts driven into the right bank of the river. Bench mark No. 1 is a large nail in the root of a tree 15 feet northwest of the end of the cable on left bank of river. Bench mark No. 2 is a large nail in the root of a tree 25 feet southwest of the end of the inclined gage. Both bench marks are 7.54 feet above gage datum. While the banks are not high, the river has never been known to overflow. The current is swift; the bed is composed of small stones and the cross section does not change materially. Discharge measurements are made from a box suspended from a five-eighth inch wire cable fastened to trees on each side of the river. The observer is J. S. Regan. The following discharge measurements were made in 1897 by F. Cogswell:

April 26, gage height, 3.00 feet; discharge, 1,507 second-feet.
May 17, gage height, 4.05 feet; discharge, 3,014 second-feet.
May 29, gage height, 5.45 feet; discharge, 4,898 second-feet.
June 28, gage height, 3.30 feet; discharge, 1,769 second-feet.
July 26, gage height, 2.00 feet; discharge, 640 second-feet.
August 30, gage height, 1.55 feet; discharge, 373 second-feet.
October 25, gage height, 2.66 feet; discharge, 1,113 second-feet.

Daily gage height, in feet, of Rio Grande at Del Norte, Colorado, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	2.18	3.40	5.42	3.40	1.88	1.48	2.22	2.36	.....
2	1.86	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	.....	.....	.....	2.24	3.52	5.30	3.56	1.90	1.54	2.50	2.28	.....
4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.30
5	.....	.....	.....	2.24	3.14	5.20	3.18	1.86	1.70	3.36	2.26	.....
6	.....	2.78	2.98	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	.....	.....	.....	2.16	3.86	4.42	2.76	1.92	2.00	3.08	2.18	.....
8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	2.64	.....	.....	2.00	4.14	4.60	3.00	1.96	1.78	3.54	2.14	.....
10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	.....	.....	.....	1.96	4.08	4.78	2.84	1.84	1.76	3.26	2.22	2.18
12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
13	.....	2.82	2.64	2.04	4.26	4.76	2.62	1.76	2.48	3.38	2.12	.....
14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	.....	.....	.....	2.24	4.48	4.82	2.50	1.72	2.12	3.50	2.00	.....
16	2.52	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
17	.....	.....	.....	2.90	4.22	4.16	2.48	1.76	1.98	3.24	1.98	.....
18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.86
19	.....	.....	.....	3.46	4.50	3.84	2.32	1.70	2.02	3.12	1.96	.....
20	.....	2.84	2.38	.....	.....	.....	.....	.....	.....	.....	.....	.....
21	.....	.....	.....	3.20	4.36	3.92	2.18	1.64	2.00	2.96	1.94	.....
22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
23	2.72	.....	.....	2.60	5.12	4.00	2.14	1.60	2.06	2.82	1.90	.....
24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
25	.....	.....	.....	2.70	5.56	3.56	2.10	1.56	2.20	2.66	1.86	2.72
26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
27	.....	2.76	2.04	2.94	5.70	3.16	1.98	1.54	2.46	2.54	1.84	.....
28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
29	.....	.....	.....	3.04	5.40	3.38	1.94	1.52	2.24	2.46	1.88	.....
30	2.70	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.92	.....
31	.....	.....	2.12	.....	5.58	.....	1.92	1.50	.....	2.44	.....	2.66

EMBUDO STATION ON RIO GRANDE.

This station, described in the Eighteenth Annual Report, Part IV, page 248, is located about 300 feet east of the railroad depot of Embudo, New Mexico. The observer is A. H. Wasson. Equipment consists of a five-eighths inch cable and car with tagged wire. The gage is inclined, and consists of 4 by 4 timber, notched and marked every tenth of a foot vertically and spiked to small hand-driven piles. The bench marks are as follows: No. 1 is a rock near the end of cable, left bank, marked "B. M." with white paint, and is 20.66 feet above datum. No. 2, rock 100 feet above cable, left bank, marked similarly and is 18.79 feet above datum; No. 3, notch cut in southeast corner of station house 2 feet above platform and is 30.48 feet above datum. The initial point of sounding is on the right bank. The left bank is steep and the right bank of more gentle slope. The following discharge measurements were made in 1897 by P. E. Harroun:

February 27, gage height, 7.90 feet; discharge, 414 second-feet.
March 19, gage height, 8.80 feet; discharge, 672 second-feet.
June 10, gage height, 12.20 feet; discharge, 5,122 second-feet.
June 23, gage height, 10.55 feet; discharge, 2,735 second-feet.
July 11, gage height, 9.50 feet; discharge, 1,527 second-feet.
July 24, gage height, 8.30 feet; discharge, 640 second-feet.
August 12, gage height, 7.40 feet; discharge, 312 second-feet.
August 29, gage height, 7.60 feet; discharge 273 second-feet.
September 13, gage height, 7.60 feet; discharge, 296 second-feet.
October 8, gage height, 9.60 feet; discharge, 1,501 second-feet.
October 25, gage height, 9.70 feet; discharge, 1,511 second-feet.

Daily gage height, in feet, of Rio Grande at Embudo, New Mexico, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.70	7.70	8.10	8.80	10.85	13.85	9.90	7.60	7.60	8.20	9.50	8.70
2	7.70	7.70	8.25	8.75	11.15	13.90	9.80	7.60	7.60	8.30	9.50	8.50
3	7.70	7.80	8.20	8.70	11.25	13.75	9.75	7.60	7.70	8.30	9.50	8.50
4	7.70	7.85	8.20	8.70	11.60	13.35	9.65	7.50	7.60	9.05	9.50	8.40
5	7.70	7.90	8.05	8.75	11.55	12.95	9.60	7.45	7.55	8.45	9.60	8.20
6	7.70	7.90	7.95	8.70	11.35	12.45	9.50	7.40	7.50	8.30	9.60	8.30
7	7.70	7.90	7.90	8.90	11.35	12.10	9.35	7.50	7.50	8.60	9.50	8.20
8	7.70	7.90	7.90	8.90	11.30	12.10	9.55	7.55	7.50	9.60	9.50	8.25
9	7.70	7.90	8.10	9.05	11.40	12.10	9.70	7.60	7.50	9.80	9.50	8.40
10	7.70	7.90	8.20	9.10	11.65	12.10	9.50	7.50	7.50	9.80	9.50	8.40
11	7.70	7.95	8.05	9.15	12.00	12.30	9.50	7.50	7.60	10.10	9.50	8.30
12	7.70	7.95	8.25	9.30	12.00	12.35	9.55	7.40	7.60	10.20	9.50	8.40
13	7.70	7.90	8.25	9.30	11.85	12.45	9.65	7.40	7.65	10.15	9.50	8.30
14	7.80	7.90	8.30	9.30	11.90	12.40	9.65	7.35	7.60	10.10	9.50	8.10
15	7.90	7.85	8.25	9.45	11.95	12.40	10.36	7.30	7.60	10.15	9.50	8.20
16	7.90	7.80	8.30	9.50	12.15	12.35	10.00	7.40	7.70	10.20	9.50	8.30
17	7.90	7.95	8.40	9.55	12.20	12.25	9.50	7.50	7.70	10.20	9.40	8.30
18	7.90	7.90	8.40	9.95	12.25	12.00	9.50	7.45	7.75	10.25	9.35	8.40
19	7.95	7.90	8.40	10.30	12.55	11.70	9.35	7.40	7.80	10.30	9.20	8.30
20	8.00	7.90	8.50	10.35	13.05	11.20	9.05	7.40	7.80	10.25	9.00	8.30
21	8.00	7.85	8.60	10.70	13.40	11.00	8.80	8.90	7.80	10.15	9.00	8.40
22	8.00	7.85	8.60	10.70	13.40	10.75	8.70	7.60	7.85	9.55	8.90	8.30
23	8.00	7.90	8.45	10.75	13.20	10.50	8.55	7.60	7.90	10.15	8.85	8.20
24	8.00	7.80	8.20	10.60	13.10	10.45	8.30	7.60	7.85	9.95	8.80	8.30
25	8.00	7.80	8.45	10.45	13.10	10.40	8.10	7.55	7.95	9.70	8.70	8.40
26	7.85	8.15	8.45	10.30	13.50	10.40	8.00	7.50	8.00	9.70	8.70	8.30
27	7.70	7.90	8.60	10.50	13.55	10.40	8.00	7.50	8.00	9.90	8.70	8.30
28	7.70	8.00	8.80	10.75	13.90	10.30	7.85	7.55	8.00	10.15	8.70	8.30
29	7.70	.....	8.95	10.85	14.00	10.20	7.80	7.60	8.10	9.90	8.70	8.30
30	7.70	.....	9.00	10.75	13.80	10.85	7.75	7.60	8.10	9.60	8.70	8.30
31	7.70	.....	8.85	.....	13.80	.....	7.65	7.60	.....	9.50	.....	8.40

ABIQUIU STATION ON CHAMA RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 252, is located about 200 yards above the town of Abiquiu, New Mexico. The gage consists of two pieces of 4 by 4 inch timbers laid on the slope of the river bank and spiked to hand-driven piles. The gaging equipment consists of five-eighths inch cable, car, and tagged wire. The initial point for soundings is on the left bank. The channel is straight, both above and below the station, for a distance of about 300 feet, although at stages of very low water it is likely to divide and swing in the main bed. The right bank is steep and rocky, but the left is liable to overflow during an excessive flood. The observer is Henry Grant. This station was discontinued on April 7, 1897. The following is a list of discharge measurements made during 1897 by P. E. Harroun:

February 26, gage height, 2.20 feet; discharge, 66 second-feet.
March 18, gage height, 3.00 feet; discharge, 318 second-feet.

Daily gage height, in feet, of Chama River at Abiquiu, New Mexico, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	Day.	Jan.	Feb.	Mar.	Apr.	Day.	Jan.	Feb.	Mar.	Apr.
1...	3.40	2.10	2.35	4.15	12...	1.95	2.15	3.15	.....	23...	1.95	2.00	3.70	.....
2...	2.55	2.10	2.35	3.95	13...	1.90	2.00	3.00	.....	24...	2.00	1.95	4.05	.....
3...	2.40	2.05	2.50	4.20	14...	3.45	2.00	3.05	.....	25...	2.05	2.10	3.70	.....
4...	2.25	2.05	3.55	5.10	15...	3.25	2.00	2.90	.....	26...	2.15	2.05	3.70	.....
5...	2.20	2.00	3.55	4.85	16...	3.00	2.00	2.90	.....	27...	2.15	2.15	4.10	.....
6...	2.05	2.15	3.20	5.75	17...	2.45	2.00	3.15	.....	28...	2.05	2.25	4.05	.....
7...	1.90	2.05	2.90	4.85	18...	2.30	2.25	3.25	.....	29...	2.10	.....	4.10	.....
8...	2.05	2.15	3.05	.....	19...	2.20	2.40	3.15	.....	30...	2.10	.....	3.95	.....
9...	2.10	1.95	2.95	.....	20...	2.05	2.15	2.95	.....	31...	1.95	.....	3.85	.....
10...	2.05	2.00	2.80	.....	21...	2.00	2.05	3.05	.....					
11...	2.10	2.10	2.85	.....	22...	2.15	2.05	3.25	.....					

RIO GRANDE STATION ON RIO GRANDE.

This station, described in the Eighteenth Annual Report, Part IV, page 252, is located about one-fourth of a mile above the railroad station, Rio Grande, New Mexico. The equipment consists of a five-eighths inch wire cable, car, and tagged wire. The gage is inclined, and consists of two timbers 4 inches square fastened to hand-driven piles and wired to solid rocks. The bench mark is on the top of a bowlder, to which the upper portion of the gage is fastened, and is 17.815 feet above gage datum. Measurements are made from the car suspended from the cable. The bed of the stream is rocky and is confined between high banks. The observer is L. M. Fewell. The following discharge measurements were made in 1897 by P. E. Harroun:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Feb. 25	4.90	487	July 10	5.90	1,757	Sept. 24	5.20	637
Mar. 17	5.83	1,003	July 23	5.20	995	Oct. 7	6.10	1,584
May 15	10.50	10,892	Aug. 11	4.80	406	Oct. 24	7.00	2,712
June 9	8.80	6,794	Aug. 28	4.20	266			
June 22	7.20	3,470	Sept. 12	5.70	1,044			

Daily gage height, in feet, of Rio Grande at Rio Grande, New Mexico, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.00	4.95	5.20	6.10	9.50	10.50	6.50	4.70	4.40	5.40	6.20	5.15
2	4.75	4.95	5.25	6.10	10.00	10.50	6.30	4.55	4.20	5.45	6.20	5.15
3	4.70	5.10	5.90	6.00	10.35	10.20	6.10	4.00	4.45	5.40	6.20	5.05
4	4.65	5.10	6.30	6.05	10.90	10.20	6.00	4.90	4.30	5.50	6.20	4.80
5	4.35	4.95	5.40	6.00	10.55	9.70	6.00	4.70	4.20	7.40	6.20	4.80
6	4.30	5.00	5.15	6.60	9.95	9.25	6.00	4.90	4.20	6.35	6.10	4.80
7	4.85	5.00	5.15	7.25	9.80	9.00	5.90	4.80	4.80	6.25	6.00	4.05
8	4.75	5.00	5.22	7.40	10.05	8.90	5.90	4.80	4.50	6.60	5.90	5.20
9	4.70	4.95	5.80	6.85	10.40	8.80	5.80	4.80	5.05	7.00	5.80	5.20
10	4.85	5.00	5.70	6.80	10.55	8.90	6.15	4.80	5.45	7.55	5.75	5.30
11	5.00	5.00	5.55	7.10	10.85	9.00	6.20	4.80	5.35	7.20	5.70	5.30
12	5.05	4.90	5.40	7.25	10.60	9.10	6.20	4.80	5.70	7.15	5.75	5.35
13	5.00	5.00	5.40	7.40	10.50	9.20	6.05	5.15	5.90	7.10	5.80	4.80
14	4.90	5.05	5.35	7.40	10.50	9.25	6.00	4.55	6.70	7.00	5.80	4.80
15	5.05	4.90	5.20	7.75	10.45	9.20	6.10	4.50	5.60	6.90	5.90	4.70
16	5.05	4.82	5.02	8.25	10.55	8.95	6.20	4.30	5.20	6.60	5.90	4.80
17	4.85	4.90	5.85	8.30	10.40	8.60	7.00	5.85	4.95	6.70	5.80	5.20
18	4.70	4.95	5.65	8.70	10.30	8.35	7.00	5.25	5.00	7.05	5.80	5.00
19	4.65	5.00	5.60	8.95	12.35	8.20	6.35	5.00	5.05	7.10	5.70	4.95
20	4.60	5.05	5.65	9.15	12.25	7.70	5.95	4.70	5.10	7.00	5.70	5.00
21	4.70	5.10	5.50	9.30	11.70	7.45	5.65	4.60	5.10	6.85	5.70	4.95
22	4.65	4.90	5.55	9.25	11.60	7.25	5.35	5.25	5.10	6.70	5.70	4.70
23	4.80	4.85	5.35	9.45	11.25	7.05	5.20	4.85	5.20	6.55	5.60	4.50
24	4.80	4.90	5.25	9.15	10.80	6.95	5.20	4.75	5.30	6.55	5.60	4.80
25	4.80	4.95	5.45	9.10	10.60	6.85	5.10	4.65	5.30	6.50	5.60	4.90
26	4.85	5.05	5.75	9.20	10.90	6.50	4.95	4.50	5.30	6.50	5.60	4.80
27	4.85	5.05	6.35	9.80	10.90	6.65	4.75	4.30	5.35	6.50	5.60	4.85
28	4.70	5.05	6.40	9.82	11.00	6.75	4.60	4.20	5.50	6.40	5.60	4.90
29	4.70	.....	6.85	9.40	11.00	6.60	4.45	4.20	5.40	6.30	5.45	4.90
30	4.95	.....	6.80	9.40	10.90	6.55	4.40	5.25	5.40	6.30	5.25	5.00
31	5.00	.....	6.32	.....	11.20	.....	4.30	4.50	.....	6.30	.....	5.00

SAN MARCIAL STATION ON RIO GRANDE.

This station, as described in the Eighteenth Annual Report, Part IV, page 254, is located at the railway bridge one-half mile south of San Marcial, New Mexico. The wire gage is attached to the guard rail of the bridge, lower side, south span. Bench marks: The 13-foot mark is level with the extension of the pier to which the old gage was fastened; the 15-foot mark is level with the top of the capstone on which the bridge truss rests. The channel is sandy and shifting. Several bridge piers also break the current. The observer is H. C. Lohman. The following discharge measurements were made by P. E. Harroun in 1897:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Feb. 21	7.40	344	June 7	9.60	9,141	Aug. 18	5.20	5
Mar. 24	7.50	478	June 21	8.70	4,142	Aug. 26	5.60	23
Apr. 9	7.50	800	June 29	8.10	2,811	Sept. 4	5.10	7
Apr. 9	8.00	1,650	July 8	7.40	1,053	Sept. 19	8.00	4,276
Apr. 20	8.50	3,165	July 16	7.70	1,150	Oct. 3	7.00	816
May 5	10.20	8,679	July 30	7.00	401	Oct. 15	8.10	3,980
May 19	10.00	10,403	Aug. 9	6.60	188	Oct. 28	8.10	3,796

Daily gage height, in feet, of Rio Grande at San Marcial, New Mexico, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.50	7.40	7.50	8.50	9.50	10.15	7.80	6.60	5.00	7.00	8.00	7.90
2	7.50	7.40	7.50	8.20	9.50	10.05	7.90	6.60	5.00	7.00	8.00	7.80
3	7.50	7.40	7.50	7.60	9.50	10.00	7.95	6.40	5.10	6.90	8.00	7.70
4	7.40	7.40	7.50	7.60	9.80	9.75	7.60	6.30	5.10	6.90	7.90	7.70
5	7.40	7.40	7.50	7.60	10.25	9.80	7.60	6.65	7.60	8.45	7.90	7.70
6	7.40	7.40	7.50	7.60	10.65	9.60	7.50	6.90	7.75	9.40	8.00	7.80
7	7.40	7.40	7.50	7.60	11.20	9.50	7.50	6.60	7.10	8.55	8.00	7.90
8	7.40	7.40	7.50	7.60	10.75	9.25	7.40	6.95	6.80	8.10	8.00	7.70
9	7.40	7.40	7.50	7.90	10.50	9.05	7.60	6.55	6.35	8.25	7.90	7.70
10	7.40	7.40	7.50	8.00	10.50	9.00	7.70	6.25	6.80	11.00	8.00	7.70
11	7.40	7.40	7.50	8.30	10.50	9.00	7.80	6.00	6.40	9.15	8.00	7.70
12	7.25	7.40	7.50	8.30	10.50	9.15	7.55	6.00	6.85	8.65	7.80	7.70
13	7.25	7.40	7.50	8.30	10.50	9.20	7.85	5.90	8.30	8.40	7.60	7.70
14	7.25	7.40	7.45	8.60	10.50	9.25	7.60	5.90	8.50	8.30	7.60	7.70
15	7.12	7.40	7.55	8.95	10.50	9.20	7.55	5.85	7.75	8.20	7.60	7.80
16	7.00	7.40	7.65	8.50	10.50	9.00	7.50	5.70	7.35	8.10	7.60	7.80
17	7.00	7.48	7.50	8.50	10.50	9.00	7.50	5.60	7.50	8.00	7.80	7.70
18	7.00	7.45	7.40	8.50	10.50	8.95	7.50	5.30	7.20	8.00	7.80	7.70
19	7.00	7.45	7.40	8.50	10.50	9.00	7.80	5.20	7.65	8.00	7.90	7.70
20	7.00	7.45	7.40	8.65	11.55	8.90	7.70	5.85	7.00	8.20	7.90	7.70
21	7.00	7.45	7.40	9.15	12.35	8.70	7.50	5.90	6.80	8.30	7.90	7.70
22	7.00	7.50	7.48	9.40	12.35	8.55	7.40	5.85	6.80	8.40	7.90	7.70
23	7.00	7.50	7.50	9.75	11.70	8.40	7.40	5.70	6.80	8.30	7.90	7.70
24	7.00	7.50	7.50	9.50	10.00	8.20	7.40	5.60	7.00	8.20	7.80	7.70
25	7.30	7.50	7.80	9.50	10.00	8.15	7.30	5.75	7.70	8.20	7.80	7.70
26	7.30	7.50	7.65	9.50	10.00	8.00	7.30	5.70	8.25	8.20	7.80	7.70
27	7.30	7.50	7.60	9.50	10.00	7.85	7.30	5.65	8.15	8.20	7.80	7.70
28	7.32	7.50	7.60	9.50	10.00	8.40	7.30	5.65	7.65	8.10	7.80	7.70
29	7.40	.....	7.60	6.50	10.00	8.00	7.15	5.55	7.35	8.10	7.80	7.70
30	7.40	.....	7.60	9.50	10.80	7.85	7.00	5.35	7.00	8.20	7.90	7.70
31	7.40	.....	7.70	.....	10.60	.....	6.80	5.00	.....	8.20	.....	7.70

EL PASO STATION ON RIO GRANDE.

This station, as described in the Eighteenth Annual Report, Part IV, page 259, was located at the pumping house of the smelter company 3 miles north of El Paso, Texas. The bed of the stream here is composed of mud, constantly shifting and changing. May 1, 1897, the station was placed under the charge of W. W. Follett, consulting engineer, International (Water) Boundary Commission, and by him removed 1 mile farther up the river to Courchesne's limekiln. The river heights are measured at the masonry pump foundation pier 150 feet above the kiln. The top of the downstream chisel draft on this pier was assumed to be at gage height 15.0 feet, and the distance of the surface of the water below it was measured with a carefully graduated rod. The left bank of the river is formed by the loose rock fill of the Atchison, Topeka and Santa Fe Railroad embankment, and will not overflow. The right bank, however, is not so good, being made ground and subject to overflow. The bottom of the river here has also proven unstable, scouring on a rise and filling on a falling river. It is probably the best site for a station in the vicinity of El Paso, however, as the entire river bed is constantly shifting for many miles above and below. On account of this shifting character of the stream, the only accurate method of estimating the daily discharges is by taking a large number of measurements, which was done in 1897 as follows, by P. E. Harroun, W. W. Follett, and T. M. Courchesne:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Feb. 22	6.60	195	May 23	13.40	8,816	June 21	10.00	5,227
Mar. 25	6.00	52	May 24	13.70	10,088	June 23	9.60	4,100
Apr. 10	7.00	242	May 25	14.10	10,421	June 25	8.90	2,809
May 4	11.40	5,355	May 26	14.35	11,583	June 26	8.40	2,474
May 5	11.35	5,277	June 4	12.60	10,410	July 1	10.40	5,617
May 7	11.45	5,891	June 7	12.30	9,448	July 3	9.60	3,931
May 8	11.95	6,588	June 11	10.70	7,175	July 6	8.30	1,733
May 11	12.50	7,241	June 12	10.30	5,228	July 8	7.60	976
May 12	11.85	6,810	June 14	10.20	4,980	July 10	7.50	1,059
May 19	12.20	7,407	June 16	10.10	5,340	July 16	7.90	1,288
May 21	12.40	8,099	June 18	10.10	5,424	July 17	7.60	902
May 22	12.80	9,803	June 19	10.20	5,446	July 19	7.50	865

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.ft.*		*Feet.*	*Sec.ft.*		*Feet.*	*Sec.ft.*
July 24	6.90	716	Sept. 20	8.20	1,042	Nov. 22	8.00	1,033
July 26	6.70	508	Sept. 23	7.20	555	Nov. 25	8.00	1,049
July 29	6.40	385	Sept. 25	6.60	317	Nov. 27	7.90	999
July 31	6.20	302	Sept. 27	6.65	347	Nov. 29	8.10	959
Aug. 2	6.10	229	Sept. 29	7.75	1,289	Dec. 1	8.10	886
Aug. 4	5.80	100	Oct. 2	7.50	599	Dec. 3	7.80	917
Aug. 6	5.70	68	Oct. 22	8.55	1,403	Dec. 6	7.60	645
Aug. 9	5.60	57	Oct. 25	8.80	1,463	Dec. 8	7.50	534
Aug. 11	5.50	50	Oct. 29	8.80	1,406	Dec. 11	7.80	678
Aug. 13	5.90	178	Nov. 1	8.90	1,654	Dec. 13	7.30	503
Aug. 14	5.80	139	Nov. 3	8.60	1,493	Dec. 15	7.40	582
Aug. 17	5.50	53	Nov. 6	8.40	1,332	Dec. 18	7.80	687
Aug. 19	7.00	495	Nov. 8	8.30	1,162	Dec. 20	7.60	657
Aug. 22	6.40	228	Nov. 10	8.40	1,215	Dec. 22	7.00	467
Sept. 10	6.50	261	Nov. 13	8.40	1,242	Dec. 24	7.30	541
Sept. 12	6.65	308	Nov. 15	8.10	1,006	Dec. 27	7.40	583
Sept. 14	7.20	702	Nov. 17	7.90	882	Dec. 29	7.50	616
Sept. 16	9.05	2,882	Nov. 19	8.20	1,248			
Sept. 18	8.60	1,892	Nov. 20	8.10	1,034			

Daily gage height, in feet, of Rio Grande at El Paso, Texas, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.60	6.90	6.30	6.05	a11.30	12.70	10.30	6.20	(b)	7.85	8.90	8.10
2	6.60	6.90	6.30	6.00	11.40	12.60	9.90	6.10	(b)	7.40	8.70	8.00
3	6.70	6.80	6.20	5.90	11.50	12.80	9.00	5.95	(b)	7.00	8.60	8.00
4	6.70	6.80	6.20	6.75	11.40	12.60	8.60	5.80	(b)	6.65	8.50	7.95
5	6.75	6.80	6.20	7.80	11.35	12.55	8.20	5.80	6.10	6.45	8.45	7.85
6	6.80	6.80	6.15	7.50	11.40	12.55	8.20	5.70	5.95	6.35	8.40	7.85
7	7.20	6.85	6.10	7.05	11.50	12.25	7.70	5.60	5.90	6.15	8.40	7.70
8	6.95	6.80	6.00	7.00	12.00	11.95	7.55	5.60	6.40	7.00	8.35	7.55
9	6.65	6.70	6.00	7.00	12.65	11.70	7.30	5.60	6.10	10.15	8.40	7.70
10	6.45	6.75	5.90	7.00	13.40	11.05	7.60	5.60	6.60	9.55	8.40	7.90
11	6.45	6.85	5.90	7.00	12.65	10.65	8.40	5.50	6.60	9.45	8.40	8.00
12	6.20	6.85	5.80	7.95	11.75	10.30	7.90	5.40	6.70	10.60	8.40	7.75
13	6.20	6.80	5.85	8.50	11.55	10.25	7.90	5.80	7.05	11.15	8.40	7.35
14	6.20	6.80	6.35	8.40	11.70	10.15	7.90	5.80	7.40	10.00	8.25	7.40
15	6.20	6.90	6.20	8.30	11.95	9.90	7.95	5.60	7.30	9.20	8.10	7.35
16	6.20	6.85	6.20	8.30	12.05	10.10	7.85	5.70	9.10	8.90	8.10	7.40
17	7.50	6.80	6.10	8.50	12.35	10.10	7.55	5.50	8.90	8.65	7.95	7.40
18	8.25	6.80	6.05	8.60	12.35	10.15	7.45	6.50	8.60	8.75	8.00	7.80
19	8.00	6.75	6.00	8.60	12.20	10.15	7.50	7.20	8.70	8.70	8.15	7.75
20	7.60	6.70	6.00	8.80	12.10	10.10	7.20	6.80	8.10	8.60	8.10	7.55
21	7.35	6.60	6.00	9.05	12.60	10.05	6.90	6.50	7.90	8.60	8.15	7.25
22	7.30	6.60	6.35	9.15	12.80	9.75	7.20	6.40	7.50	8.55	8.05	7.00
23	7.20	6.50	6.30	9.80	13.25	9.55	7.70	6.10	7.20	8.60	8.10	7.20
24	7.20	6.50	6.20	10.05	13.80	9.20	6.90	5.90	7.00	8.85	8.05	7.35
25	7.20	6.45	6.00	10.15	14.15	8.80	6.75	5.70	6.70	8.80	7.95	7.50
26	7.10	6.50	5.85	10.25	14.45	8.35	6.70	5.50	6.50	8.70	7.85	7.50
27	7.00	6.40	5.75	10.45	15.30	8.20	7.30	(b)	6.70	8.70	7.95	7.40
28	6.90	6.35	5.75	10.50	14.20	8.05	6.40	(b)	7.15	8.80	7.95	7.50
29	6.75	.....	5.60	10.45	13.35	8.05	6.30	(b)	7.85	8.80	8.10	7.60
30	6.80	.....	5.80	10.40	12.90	9.30	6.25	(b)	8.35	8.80	8.00	7.35
31	6.80	.....	6.00	.....	12.70	.....	6.20	(b)	.....	8.70	.....	7.20

a Location of gaging station changed. b No flow.

GRANGER STATION ON BLACKS FORK.

The old station, described in the Eighteenth Annual Report, Part IV, page 270, was located 3 miles west of Granger, Wyoming, at the Union Pacific railroad bridge, and above Hams Fork. On April 28 the location was abandoned and the station was removed to a point below Hams Fork, about one-fourth of a mile below Granger. The new rod consists of a horizontal timber 4 by 4 inches by 16 feet, fastened to two upright posts 6 feet apart and set firmly in the bank of the river above high-water mark. One end of this horizontal timber, to which the wire gage is fastened, projects out over the water. The length of the gage wire is 13.35 feet. The distance from the outside edge of the pulley to the zero of the rod is 2.45 feet. The bench mark is a rail spike in an old tie 24 feet southwest of inside post of gage. The letters "B. M." are marked in black paint on the tie. The elevation of the head of the spike above datum is 8.74 feet. The observer, pump man for the railroad, is J. R. Kirby. Discharge measurements are made from a cable and car 400 feet below the rod. The following are those made in 1897, by C. T. Johnston:

May 7, gage height, 4.55 feet; discharge, 3,724 second-feet.
May 18, gage height, 4.60 feet; discharge, 4,079 second-feet.
May 26, gage height, 5.10 feet; discharge, 4,976 second-feet.
June 3, gage height, 3.60 feet; discharge, 2,910 second-feet.
June 10, gage height, 2.75 feet; discharge, 1,758 second-feet.
June 15, gage height, 2.45 feet; discharge, 1,432 second-feet.
August 9, gage height, 0.40 foot; discharge, 222 second-feet.

Daily gage height, in feet, of Blacks Fork at Granger, Wyoming, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	3.00	2.80	4.00	1.00	0.20	—0.10	0.65	.....	.....
2	2.90	.....	.....	3.20	3.05	3.85	1.00	.20	— .10	1.50	.....	.....
3	.....	.....	.....	2.90	3.20	3.50	1.05	.20	— .10	.....	.....	.....
4	.....	.....	.....	3.20	3.35	3.20	1.20	.30	— .10	.....	.....	0.80
5	.....	.....	.....	3.20	3.70	2.90	1.15	.30	+ .05	.....	.....	.....
6	.....	2.90	2.90	2.90	4.20	2.65	1.05	.30	.00	.....	.....	.....
7	.....	.....	.....	a3.60	4.55	2.50	.95	.35	.00	.....	0.60	.....
8	.....	.....	.....	3.40	4.95	2.40	.90	.40	.00	.....	.....	.....
9	2.90	.....	.....	3.20	5.10	2.50	.85	.40	.00	.90	.....	.....
10	.....	.....	.....	3.50	4.95	2.65	.80	.40	.00	.....	.....	.....
11	.....	.....	.....	5.50	4.60	2.70	.70	.40	.00	.....	.....	1.20
12	.....	.....	.....	4.60	4.10	2.50	.70	.40	.00	.....	.....	.....
13	.....	2.90	2.90	4.20	3.85	2.30	.60	.35	.00	.....	.60	.....
14	.....	.....	.....	3.70	4.10	2.40	.60	.30	.10	.....	.....	.....
15	.....	.....	.....	3.50	4.25	2.30	.60	.30	.10	.....	.....	.....
16	2.90	.....	.....	3.90	4.50	2.25	.60	.30	.20	.80	.....	.....
17	.....	.....	.....	4.20	4.55	2.05	.60	.20	.30	.....	.....	.....
18	.....	.....	.....	4.40	4.60	2.05	.60	.20	.30	.....	.....	.....
19	.....	.....	2.90	4.60	4.50	1.75	.60	.10	.30	.....	.....	1.10
20	.....	2.90	.....	4.60	4.55	1.60	.55	.10	.25	.....	.50	.....
21	.....	.....	.....	4.50	5.05	1.45	.50	.10	.20	.....	.....	.....
22	.....	.....	.....	4.20	5.30	1.40	.50	.10	.20	.....	.....	.....
23	2.90	.....	.....	3.60	5.30	1.40	.50	.10	.20	.60	.....	.....
24	.....	.....	.....	3.30	5.60	1.30	.50	.05	.20	.....	.....	.....
25	.....	.....	.....	3.30	5.40	1.20	.40	.00	.20	.....	.....	1.10
26	.....	.....	.....	3.20	4.95	1.20	.40	.00	.25	.....	.....	.....
27	.....	2.90	2.90	3.50	4.70	1.10	.35	.00	.35	.....	.....	.....
28	.....	.....	.....	b1.90	4.35	1.05	.30	.00	.40	.....	.....	.....
29	.....	.....	.....	2.30	4.20	1.10	.30	.00	.50	.....	.....	.....
30	2.90	.....	.....	2.50	4.20	1.10	.20	.00	.50	.....	.....	.....
31	.....	.....	.....	.....	4.05	.....	.20	.00	.....	.....	.....	.....

a New wire gage.
b Station moved to one-fourth mile below Granger, Wyoming.

GREENRIVER STATION ON GREEN RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 272, is located at Greenriver, Wyoming. The rod is fastened to an old pile near the east end of the bridge at the pump house of the railroad company. The pumpman in charge, William Slater, is the observer. The bench mark consists of a cross on the third step from the bottom on the south end of east abutment, and is 12.48 feet above datum. The section under the railroad bridge is poor, and discharge measurements are made from the new iron highway bridge one-half mile below. The channel here is straight for some distance above and below. The banks are medium high, and the bed is composed of small cobblestones and gravel, being quite permanent in character. The following discharge measurements were made by Cyrus C. Babb and C. T. Johnston in 1897:

April 27, gage height, 1.85 feet; discharge, 1,820 second-feet.
May 7, gage height, 3.30 feet; discharge, 6,970 second-feet.
May 18, gage height, 4.00 feet: discharge, 9,325 second-feet.
May 26, gage height, 5.35 feet; discharge, 15,318 second-feet.
June 3, gage height, 5.10 feet; discharge, 14,896 second-feet.
June 10, gage height, 3.45 feet; discharge, 6,104 second-feet.
June 15, gage height, 3.60 feet; discharge, 7,094 second-feet.
August 9, gage height, 2.00 feet; discharge, 2,081 second-feet.

Daily gage height, in feet, of Green River at Greenriver, Wyoming, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	.....	.....	1.88	2.35	4.80	2.85	1.85	1.10	1.00	1.25
2	.....	.....	.....	1.75	2.50	4.92	2.75	1.95	1.05	1.32	.....
3	1.80	.....	.....	1.55	2.55	5.08	2.75	2.02	1.00	.....	1.25
4	.....	.....	.....	1.50	2.72	4.80	2.85	2.25	0.98	.....	.....
5	.....	2.20	2.15	1.58	2.95	4.40	3.00	2.22	.95	.....	1.20
6	.....	2.20	2.15	1.52	3.15	4.12	2.92	2.18	.95	.....	.....
7	.....	.....	.....	1.50	3.32	3.82	2.75	2.08	1.00	.....	.....
8	1.80	.....	.....	1.52	3.45	3.55	2.65	2.10	1.00	.....	1.20
9	1.80	.....	.....	1.48	3.68	3.48	2.58	2.02	.95	.....	.....
10	.....	.....	.....	1.45	3.65	3.58	2.50	2.10	1.00	.....	1.20
11	.....	.....	.....	1.55	3.58	3.68	2.50	2.05	1.00	1.35	.....
12	1.80	2.10	2.15	1.72	3.50	3.72	2.50	1.98	1.00	.....	1.20
13	.....	2.10	.....	1.78	3.38	3.65	2.45	1.88	1.00	1.30	.....
14	.....	.....	2.15	1.95	3.38	3.65	2.40	1.82	.95	.....	.....
15	.....	.....	.....	2.00	3.50	3.68	2.32	1.80	.95	1.25	1.20
16	1.80	.....	.....	2.05	3.68	3.75	2.30	1.80	.95	.....	.....
17	.....	.....	.....	2.15	3.88	3.75	2.25	1.75	.90	.....	1.20
18	1.80	2.10	.....	2.30	4.02	3.80	2.30	1.68	.90	1.80	.....
19	.....	.....	2.15	2.25	4.10	3.75	2.25	1.58	.90	.....	1.15
20	.....	2.10	2.15	2.35	4.25	3.55	2.25	1.50	.90	1.60	.....
21	.....	.....	.....	2.40	4.62	3.35	2.22	1.45	.90	.....	.....
22	1.90	.....	.....	2.50	5.30	3.12	2.18	1.40	.90	1.20	.....
23	.....	.....	.....	2.40	5.85	3.05	2.12	1.40	.90	.....	.....
24	1.90	.....	.....	1.85	5.58	3.00	2.10	1.35	.90	.....	.....
25	.....	.....	.....	1.78	5.42	2.98	2.02	1.32	.90	1.25	.....
26	.....	2.15	2.40	1.80	5.32	3.02	1.98	1.28	.95	.....	.....
27	.....	2.15	2.40	1.98	5.28	3.00	1.95	1.25	.95	1.30	.....
28	.....	.....	.....	2.05	5.15	3.00	1.90	1.20	.95	.....	.....
29	2.00	.....	.....	2.22	4.88	3.00	1.90	1.20	1.00	1.30	.....
30	2.00	.....	.....	2.35	4.60	2.98	1.85	1.15	1.00	.....	.....
31	.....	.....	.....	.....	4.62	.....	1.80	1.12	.....	.....	.....

BLAKE STATION ON GREEN RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 275, is located at the crossing of the Rio Grande Western Railroad at Blake, Utah. The elevation of the top of the pier, to which the old vertical rod is attached, is 22.00 feet above the rod datum. The rod of the wire gage is nailed to the guard rail on the lower side of the bridge. The distance from the end of the rod to the outside edge of the pulley wheel is 1 foot; from the end of the weight to the wire index marker, 27.67 feet. The observer is Frank Jacobs, rancher. The section at this point is good, the channel being straight for some distance above and below. The bed is gravelly. The initial point for soundings is on the right bank. The following discharge measurements were made in 1897 by Cyrus C. Babb and W. B. Dougall:

April 21, gage height, 4.88 feet; discharge, 8,175 second-feet.
May 22, gage height, 10.10 feet; discharge, 55,886 second-feet.
November 22, gage height, 2.80 feet; discharge, 3,373 second-feet.

Daily gage height, in feet, of Green River at Blake, Utah, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	.....	6.75	10.55	5.55	3.30	2.20	3.95	3.20	2.60
2	1.70	.....	.....	.....	7.05	10.25	5.35	3.30	2.20	4.50	3.20	2.50
3	.....	.....	.....	3.70	7.40	10.20	5.15	3.20	2.20	4.50	3.15	2.40
4	.....	.....	.....	3.70	7.80	10.00	5.15	3.10	2.35	4.50	3.10	2.30
5	.....	.....	.....	3.60	8.25	10.00	5.25	3.20	2.20	4.30	3.10	2.20
6	.....	1.80	2.00	3.75	8.70	9.95	5.20	3.30	2.35	4.15	3.00	2.10
7	.....	.....	.....	3.65	8.90	9.15	5.00	3.40	2.40	4.05	3.00	2.00
8	.....	.....	.....	3.50	9.05	8.60	4.90	3.50	2.55	4.35	3.00	1.90
9	1.70	.....	.....	3.50	9.25	8.20	4.80	3.50	2.70	4.55	2.90	1.90
10	.....	.....	.....	3.60	9.45	7.90	4.70	3.40	2.85	4.85	2.90	1.90
11	.....	.....	.....	3.70	9.65	7.60	4.60	3.40	3.25	4.75	2.90	1.90
12	.....	.....	.....	3.55	9.90	7.50	4.50	3.40	4.70	4.60	2.80	1.80
13	.....	1.90	.....	3.55	9.95	7.80	4.40	3.45	4.70	4.50	2.80	1.80
14	.....	.....	.....	3.70	9.85	7.70	4.30	3.50	5.30	4.35	2.80	1.70
15	.....	.....	2.00	3.95	9.25	7.80	4.20	3.50	3.70	4.10	2.80	1.70
16	1.80	.....	.....	4.15	9.15	7.70	4.10	3.40	3.40	3.85	2.80	1.60
17	.....	.....	.....	4.35	9.35	7.60	4.10	3.30	3.30	3.80	2.80	1.50
18	.....	.....	.....	4.50	9.55	7.50	4.10	3.15	2.90	3.70	2.80	1.40
19	.....	.....	.....	4.60	9.75	7.35	4.00	3.05	2.80	3.70	2.80	1.40
20	.....	1.90	2.10	4.60	9.95	7.25	4.00	2.90	2.80	3.60	2.80	1.30
21	.....	.....	.....	4.75	10.05	7.10	3.90	2.85	2.70	3.60	2.80	1.40
22	.....	.....	.....	5.00	10.05	6.95	3.90	2.70	2.60	3.50	2.80	1.30
23	1.60	.....	.....	5.45	10.05	6.75	3.80	2.70	2.50	3.50	2.80	1.20
24	.....	.....	.....	6.15	10.25	6.55	3.80	2.60	2.50	3.40	2.80	1.20
25	.....	.....	.....	6.30	10.60	6.35	3.80	2.60	2.50	3.50	2.80	1.10
26	.....	.....	.....	5.80	11.00	6.25	3.70	2.50	2.50	3.55	2.80	1.20
27	.....	1.95	2.90	5.70	11.25	6.15	3.60	2.50	2.65	3.45	2.80	1.30
28	.....	.....	.....	5.70	11.35	6.35	3.50	2.40	2.85	3.40	2.80	1.25
29	.....	.....	3.90	5.95	11.40	5.95	3.50	2.40	3.05	3.40	2.80	1.35
30	1.60	.....	.....	6.30	11.15	5.75	3.50	2.40	3.35	3.30	2.70	1.40
31	.....	.....	.....	.....	10.95	.....	3.40	2.40	.....	3.20	.....	1.30

SHOSHONE STATION ON GRAND RIVER.

This station is located at Shoshone, or Gypsum post-office, Colorado, on the line of Denver and Rio Grande Railroad, 10 miles east of Glenwood Springs, Colorado. The rod is a vertical 3 by 6 inch wooden timber set 3 or 4 feet into rock and well braced. Observations are taken by the station agent, George Ruark, under the direction of the division superintendent of the railroad company. No discharge measurements were made at this point in 1897.

Daily gage height, in feet, of Grand River at Shoshone, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Day.	May.	June.	July.	Aug.
1	4.10	13.40	6.55	1.55	17	10.35	11.40	4.00	(a)
2	5.15	13.35	6.60	1.55	18	10.90	10.25	4.00	(a)
3	5.70	12.50	7.00	1.90	19	11.05	9.35	3.60	(a)
4	6.95	10.25	6.90	2.50	20	11.10	9.25	3.50	(a)
5	7.15	9.50	6.50	2.70	21	11.45	9.50	3.00	(a)
6	8.20	8.50	5.35	2.95	22	11.00	9.85	2.45	(a)
7	8.90	8.30	4.85	2.55	23	11.75	9.95	2.50	(a)
8	9.90	7.55	5.00	2.00	24	12.65	9.55	2.40	(a)
9	10.10	8.20	6.00	2.05	25	13.35	8.85	2.60	(a)
10	9.95	9.55	6.70	1.95	26	13.20	8.60	2.50	(a)
11	9.45	10.00	5.70	1.55	27	13.00	9.00	2.25	(a)
12	8.75	10.65	5.35	1.20	28	12.85	8.60	2.20	(a)
13	8.60	11.40	4.70	1.10	29	12.95	7.55	1.75	(a)
14	9.90	11.60	4.45	1.10	30	13.25	7.05	1.80	(a)
15	9.35	11.55	4.40	1.00	31	13.30	.....	1.60	(a)
16	10.05	11.85	4.35	.90					

a Below gage.

GRAND JUNCTION STATION ON GRAND RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 260, is located at the wagon bridge across the Grand River, near the pump house of the city waterworks, Grand Junction, Colorado. The river at this point discharges through two channels. Gage rod No. 1 consists of a vertical 4 by 6 inch timber, with 1 by 6 inch scale, bolted to the bridge abutment on right-hand side of the right channel. The 12-foot mark is on a level with the top of the bridge abutment. The banks of the right channel are both liable to overflow at very high water; the bed is of sand, and the current very sluggish. The horizontal wire gage No. 2 is fastened to the upper side of the bridge over the left channel between marks 595 and 605 feet. The distance from the end of the weight to outer end of snap is 31.80 feet. The bench mark is a cross on iron post of bridge at 592 foot mark, and is 31.0 feet above datum. The right bank of the left channel is low and liable to overflow, the left is high and rocky; the bed is sandy; the water is deep and moves with considerable velocity. At high water it becomes necessary to guy the meter to a wire stretched across the channel above the bridge to prevent it from being swept down stream by the swift current. The observer is B. W. Vedder, engineer at the pumping station. The following measurements were made in 1897 by C. C. Babb and F. Cogswell in Channel No. 1:

April 20, gage height, 1.75 feet; discharge, 1,157 second-feet.
May 18, gage height, 4.80 feet; discharge, 10,927 second-feet.
July 29 to November 23 the channel was dry.

The following measurements were made in Channel No. 2:

April 20, gage height, 5.60 feet; discharge, 4,019 second-feet.
May 19, gage height, 10.20 feet; discharge, 21,759 second-feet.
July 29, gage height, 5.35 feet; discharge, 4,044 second-feet.
September 29, gage height, 4.05 feet; discharge, 2,062 second-feet.
October 28, gage height, 3.98 feet; discharge, 1,764 second-feet.
November 23, gage height, 3.90 feet; discharge, 1,423 second-feet.

Daily gage height, in feet, of Grand River at Gage No. 1, Grand Junction, Colorado, for 1897.

Day.	Apr.	May.	June.	July.	Day.	Apr.	May.	June.	July.
1	0.00	2.60	5.10	1.45	17	1.00	4.55	3.80	.00
2	.00	2.90	5.25	1.25	18	1.25	4.70	3.40	.00
3	.00	3.25	4.65	1.35	19	1.55	4.95	2.85	.00
4	.00	3.50	3.75	1.65	20	1.80	4.75	2.55	.00
5	.00	3.80	2.85	1.50	21	1.85	4.60	2.65	.00
6	.00	4.15	2.50	.90	22	1.75	4.80	2.75	.00
7	.00	4.35	2.35	.65	23	1.60	4.85	2.85	.00
8	.00	4.70	2.20	.70	24	1.45	5.10	2.75	.00
9	.00	4.90	2.15	.90	25	1.50	5.35	2.40	.00
10	.00	4.75	2.80	1.15	26	1.65	5.30	2.10	(a)
11	.00	4.50	3.05	1.05	27	2.15	5.25	2.15	(a)
12	.00	4.35	3.40	1.00	28	2.40	5.00	2.15	(a)
13	.00	4.30	3.70	.50	29	2.40	4.90	1.90	(a)
14	.00	4.35	4.00	.15	30	2.45	5.10	1.55	(a)
15	.50	4.40	4.10	.00	31	.....	5.10	.....	(a)
16	.70	4.45	4.00	.00					

a Dry for rest of year.

Daily gage height, in feet, of Grand River at Gage No. 2, Grand Junction, Colorado, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	3.50	6.75	10.30	7.95	5.10	4.00	4.00	3.85	3.80
2	2.80	.....	.....	3.60	7.20	10.55	7.75	5.15	4.00	4.00	3.90	3.90
3	.....	3.00	3.30	3.50	7.65	10.10	7.85	5.55	4.00	4.00	3.90	3.90
4	.....	.....	.....	3.40	7.90	9.30	8.15	5.75	4.00	4.00	3.90	3.70
5	.....	.....	.....	3.45	8.20	8.40	8.05	5.80	4.00	4.10	3.90	.....
6	.00	3.10	3.20	3.50	8.55	9.35	7.45	5.90	3.90	4.00	4.05	.....
7	.....	.....	.....	3.75	8.75	9.15	7.15	5.85	3.90	4.20	4.10	.....
8	.00	.....	.....	3.55	9.10	9.00	7.15	5.60	4.10	4.10	4.10	3.80
9	.....	.....	.....	3.60	9.45	8.95	7.45	5.40	4.10	4.20	4.05	.....
10	.....	.....	3.20	3.50	9.25	9.40	7.70	5.40	4.00	4.30	4.00	.....
11	.....	3.00	.....	3.60	9.00	9.75	7.75	5.30	4.20	4.20	3.85	3.80
12	.....	.....	.....	3.70	8.90	9.90	7.45	5.15	4.20	4.15	3.80	.....
13	.....	3.10	3.10	3.60	8.70	10.00	7.05	4.95	4.25	4.10	3.95	.....
14	3.00	.....	.....	3.80	8.85	10.30	6.75	4.90	4.70	4.10	4.10	.....
15	.....	.....	.....	3.90	8.90	10.35	6.65	4.90	4.45	4.10	4.10	3.80
16	3.10	.....	.....	4.10	8.95	10.25	6.60	4.75	4.25	4.10	4.00	.....
17	.....	3.10	3.40	4.55	9.10	9.95	6.60	4.60	4.10	4.50	3.90	.....
18	.....	.....	.....	4.85	9.20	9.75	6.45	4.55	4.00	4.35	3.80	3.70
19	.....	.....	.....	5.25	10.20	9.40	6.40	4.40	4.00	4.15	3.80	.....
20	.....	3.20	3.60	5.50	10.10	9.25	6.30	4.30	4.00	4.10	3.80	.....
21	2.90	.....	.....	5.65	10.00	9.20	6.15	4.30	4.00	4.00	3.95	.....
22	.....	.....	.....	5.55	10.20	9.25	5.95	4.20	4.00	4.00	3.90	3.70
23	3.00	.....	.....	5.40	10.25	9.35	5.75	4.10	4.00	4.00	3.90	.....
24	.....	3.10	3.00	5.15	10.50	9.25	5.70	4.10	3.95	4.00	3.90	.....
25	.....	.....	.....	5.20	10.70	9.00	5.60	4.05	3.90	4.10	4.10	3.80
26	.....	.....	.....	5.45	10.60	8.85	5.60	4.00	3.95	4.10	4.00	.....
27	.00	3.00	4.20	6.15	10.50	9.05	5.60	4.00	4.00	4.00	3.90	.....
28	.....	.....	.....	6.45	10.20	8.85	5.55	4.00	4.00	4.00	3.80	.....
29	.....	.....	.....	6.50	10.10	8.50	5.35	4.00	4.00	3.90	3.65	3.90
30	.00	.....	.....	6.55	10.20	8.20	5.25	4.00	4.00	3.80	3.75	.....
31	.....	.....	.....	.....	10.35	.....	5.10	4.00	.....	3.80	.....	.....

FORT CRAWFORD STATION ON UNCOMPAHGRE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 265, is located about one-half mile east of the depot at Fort Crawford, Colorado, at a wagon bridge, and is about 8 miles above Montrose. The gage consists of an inclined 4 by 4 inch timber, bolted to the bridge bent on the right-hand side of the stream. The bench mark consists of a spike driven in the base of a cottonwood post, and is 9.18 feet above zero. Both banks are low and liable to overflow at high water, and the bed of the stream is composed of sand and gravel. The observer is Mrs. F. Humphrey; post-office, Uncompahgre, Colorado. The following discharge measurements were made during 1897 by F. Cogswell.

April 18, gage height, 3.90 feet; discharge, 487 second-feet.
May 10, gage height, 4.55 feet; discharge, 884 second-feet.
June 21, gage height, 5.05 feet; discharge, 1,081 second-feet.
July 19, gage height, 4.50 feet; discharge, 473 second-feet.
August 23, gage height, 3.45 feet; discharge, 70 second-feet.
September 20, gage height, 3.85 feet; discharge, 153 second-feet.
October 18, gage height, 4.00 feet; discharge, 195 second-feet.

Daily gage height, in feet, of Uncompahgre River at Fort Crawford, Colorado, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	3.15	4.05	4.50	4.50	4.00	3.35	4.35	3.95
2	3.15	4.15	4.40	4.60	4.20	3.40	4.15	3.90
3	2.95	4.25	4.05	5.35	4.10	3.40	4.05	3.90
4	3.05	4.40	3.95	4.70	3.95	3.40	4.00	3.90
5	3.20	4.40	4.05	4.65	4.15	3.45	4.00	3.90
6	3.20	4.50	4.00	4.65	4.05	3.45	4.15	3.85
7	3.30	4.50	4.10	4.70	4.20	3.55	4.15	3.85
8	3.28	4.45	4.65	4.85	4.00	3.40	4.15	3.80
9	3.25	4.40	5.00	4.95	4.00	3.00	4.05	3.80
10	3.25	4.45	5.00	4.85	3.85	3.45	4.05	3.70
11	3.25	4.20	4.85	4.70	3.95	3.40	4.05	3.65
12	3.30	4.45	4.80	4.65	4.00	3.55	4.00	3.70
13	3.32	4.30	5.10	4.65	3.85	3.85	4.00	3.75
14	3.50	4.25	5.30	4.60	3.80	4.10	4.05	3.70
15	3.60	4.35	5.40	4.65	3.85	4.05	4.20	3.75
16	3.80	4.20	5.35	4.50	3.85	4.05	4.05	3.80
17	3.90	4.15	5.05	4.45	3.75	3.85	4.00	3.65
18	4.10	4.45	5.05	4.50	3.60	3.80	4.00	3.75
19	4.20	4.40	4.90	4.45	3.60	3.85	4.10	3.70
20	4.05	4.40	4.95	4.10	3.55	3.90	4.00	3.65
21	3.95	4.50	5.00	4.30	3.50	4.05	4.00	3.60
22	3.75	4.35	5.15	4.45	3.50	4.00	3.90	3.60
23	3.60	4.45	5.40	4.45	3.45	3.95	3.80	3.65
24	3.65	4.65	5.20	4.35	3.45	4.00	3.90	3.65
25	4.10	4.55	5.05	4.45	3.40	3.95	3.90	3.60
26	4.00	4.85	5.15	4.15	3.40	4.15	4.00	3.65
27	4.15	4.90	5.00	4.15	3.35	4.15	3.85	3.65
28	4.30	4.20	4.55	4.25	3.35	3.95	3.85	.....
29	4.30	5.00	4.90	3.85	3.40	4.05	3.85	.....
30	4.40	5.00	5.00	4.00	3.40	4.20	3.90	.....
31	.....	4.95	.....	4.00	3.40	.....	3.90	.....

ROUBIDEAU AND WHITEWATER STATIONS ON GUNNISON RIVER.

Gage heights at these stations are reported daily by telegraph to the division superintendent of the Denver and Rio Grande Railroad Company at Salida, Colorado, who has kindly furnished this office with copies of same.

Roubideau station is at the railroad bridge at Roubideau, Colorado, 6 miles west of Delta. The observer is M. J. Johnston, track foreman.

Whitewater station is located 13 miles southeast of Grand Junction at Whitewater, Colorado. The gage is a vertical rod graduated to feet and halves and securely fastened on the right bank of the river. The observer is James Page, station agent. No measurements of discharge have been made at these stations.

Daily gage height, in feet, of Gunnison River at Roubideau, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Day.	May.	June.	July.	Aug.	Day.	May.	June.	July.	Aug.
1..	3.75	4.65	1.60	0.15	12...	4.50	3.60	1.25	0.15	23...	4.50	2.85	0.50	(a)
2..	4.25	5.15	1.50	.15	13...	4.75	3.85	1.15	.15	24...	4.75	2.85	.50	(a)
3..	4.50	4.50	1.75	.15	14...	4.75	4.25	1.15	.15	25...	5.00	2.75	.25	(a)
4..	4.00	3.75	1.75	.15	15...	4.85	4.00	1.00	.15	26...	4.90	2.25	.25	(a)
5..	4.50	3.25	1.50	.15	16...	4.75	4.00	.85	.15	27...	4.85	2.35	.25	(a)
6..	5.25	2.85	1.35	.15	17...	4.50	3.75	.85	.15	28...	4.75	2.35	.15	(a)
7..	5.50	2.75	1.25	.15	18...	4.40	3.25	.85	.15	29...	4.40	2.00	.25	(a)
8..	5.75	2.85	1.25	.15	19...	4.60	2.75	.85	.15	30...	4.60	1.75	.50	(a)
9..	5.75	3.00	1.25	.15	20...	4.50	2.65	.65	(a)	31...	4.50	.....	.15	(a)
10..	5.50	3.50	1.25	.15	21...	4.40	2.85	.65	(a)					
11..	5.00	3.60	1.25	.15	22...	4.35	2.75	.50	(a)					

a Below gage.

Daily gage height, in feet, of Gunnison River at Whitewater, Colorado, for 1897.

Day.	May.	June.	July.	Day.	May.	June.	July.	Day.	May.	June.	July.
1....	4.40	5.35	1.00	12.....	5.50	4.00	(a)	23.....	5.00	3.60	(a)
2....	4.60	5.75	1.00	13.....	5.60	4.15	(a)	24.....	5.25	3.00	(a)
3....	4.85	5.25	1.00	14.....	5.65	4.35	(a)	25.....	5.60	3.00	(a)
4....	4.65	4.50	1.00	15.....	5.60	4.35	(a)	26.....	5.50	2.75	(a)
5....	4.90	3.85	.65	16.....	5.50	4.35	(a)	27.....	5.50	2.35	(a)
6....	5.60	3.60	.65	17.....	5.40	4.40	(a)	28.....	5.50	2.55	(a)
7....	5.90	3.35	.50	18.....	5.15	3.75	(a)	29.....	5.15	2.50	(a)
8....	6.35	3.15	.40	19.....	5.35	3.30	(a)	30.....	5.15	1.60	(a)
9....	6.25	3.40	.35	20.....	5.35	3.00	(a)	31.....	5.35	.....	(a)
10....	6.10	3.75	.35	21.....	5.00	3.00	(a)				
11....	5.75	4.00	(a)	22.....	5.00	3.00	(a)				

a Below gage.

GRAND JUNCTION STATION ON GUNNISON RIVER.

This station is located at the iron highway bridge 1.5 miles from the town of Grand Junction, Colorado. The gage is vertical and consists of a 2 by 6 inch timber bolted to the stone pier of the bridge. The top of the capstone is 17.60 feet above gage datum. The channel above the station is curved, but below it is nearly straight. The right bank is low and liable to overflow, but the left is high and rocky with still water at low stages. The observer is A. Lindquist, engineman at the Denver and Rio Grande Railroad Company's pump house. The following discharge measurements were made in 1897 by Cyrus C. Babb and F. Cogswell:

April 20, gage height, 4.60 feet; discharge, 5,975 second-feet.
May 20, gage height, 7.30 feet; discharge, 16,644 second-feet.
July 28, gage height, 2.65 feet; discharge, 1,814 second-feet.
September 28, gage height, 2.40 feet; discharge, 1,246 second-feet.
October 27, gage height, 2.50 feet; discharge, 1,270 second-feet.
November 23, gage height, 2.30 feet; discharge, 828 second-feet.

Daily gage height, in feet, of Gunnison River at Grand Junction, Colorado, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	7.50	4.10	2.60	1.60	2.60	2.40	1.70
2	6.10	7.90	4.00	2.60	1.60	2.50	2.40	1.90
3	6.80	7.30	4.10	2.60	1.60	2.50	2.40	2.20
4	6.90	6.70	4.40	2.80	1.50	2.40	2.40	2.10
5	6.80	5.90	4.30	2.80	1.50	2.40	2.40	.....
6	7.30	5.70	4.10	2.80	1.60	2.40	2.40	.....
7	7.70	5.50	4.00	2.70	1.70	2.40	2.40	.....
8	8.10	5.40	4.00	2.60	1.70	2.50	2.30	.....
9	8.30	5.50	4.00	2.70	1.70	2.50	2.20	.....
10	8.10	6.00	4.30	2.70	1.70	2.70	2.10	.....
11	7.80	6.40	4.20	2.60	1.80	2.90	1.90	.....
12	7.40	6.60	4.00	2.50	1.80	2.80	2.10	.....
13	7.30	6.40	3.70	2.40	1.90	2.70	2.20	.....
14	7.40	6.70	3.50	2.30	2.00	2.60	2.40	.....
15	7.50	6.70	3.30	2.20	2.20	2.60	2.40	.....
16	7.60	6.70	3.30	2.20	2.20	2.70	2.30	.....
17	7.50	6.60	3.20	2.20	2.10	2.90	2.30	.....
18	7.10	6.00	3.20	2.10	2.10	2.80	2.10	.....
19	7.30	5.60	3.20	2.00	2.00	2.70	2.00	.....
20	7.40	5.40	3.20	2.00	2.00	2.70	2.10	.....
21	7.00	5.40	3.10	2.00	1.90	2.70	2.20	.....
22	7.00	5.40	3.00	1.90	2.00	2.60	2.10	.....
23	7.00	5.50	3.00	1.80	2.20	2.60	2.10	.....
24	7.30	5.50	2.90	1.70	2.20	2.60	2.30	.....
25	7.80	5.30	2.90	1.60	2.10	2.50	2.30	.....
26	7.60	5.20	2.90	1.60	2.10	2.50	2.20	.....
27	7.50	5.00	2.80	1.60	2.20	2.40	2.20	.....
28	7.50	4.90	2.70	1.50	2.30	2.40	2.00	.....
29	7.00	4.70	2.70	1.60	2.40	2.40	1.70	.....
30	7.30	4.40	2.70	1.60	2.60	2.30	1.60	.....
31	7.30	.....	2.60	1.60	.....	2.40	.....	.....

FALL CREEK STATION ON SAN MIGUEL RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 264, is located about 300 yards southwest of Fall Creek, Colorado, a station on the Rio Grande Southern Railroad. Discharge measurements are made from the wagon bridge. The gage is vertical, 4 inches square, and is spiked to the west side of the north abutment. One bench mark is a bolthead in the north end of the west truss, 1 foot from the gage. It is 11.15 feet above the gage zero. The second bench mark is a spike driven into a tree 200 feet northwest. This is 8.65 feet above the zero. As the channel at this point is nearly straight and the banks rarely overflow, the section is a desirable one for measurements. Fall Creek empties into the San Miguel about 200 feet below the gage. The observer is Mrs. H. H. Hart; post-office address, Sawpit, Colorado. The following is a list of discharge measurements made in 1897 by F. Cogswell:

April 20, gage height, 3.40 feet; discharge, 304 second-feet.
May 11, gage height, 4.05 feet; discharge, 572 second-feet.
June 22, gage height, 4.45 feet; discharge, 811 second-feet.
July 20, gage height, 3.45 feet; discharge, 336 second-feet.
August 24, gage height, 2.85 feet; discharge, 145 second-feet.
September 21, gage height, 3.30 feet; discharge, 248 second-feet.
October 19, gage height, 3.05 feet; discharge, 197 second-feet.

Daily gage height, in feet, of San Miguel River at Fall Creek, Colorado, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	2.45	3.70	4.60	4.05	3.30	2.80	3.35	2.80
2	2.35	3.75	4.50	4.05	3.40	2.85	3.25	2.80
3	2.35	3.75	4.10	4.15	3.40	3.15	3.15	2.75
4	2.25	3.65	3.95	3.90	3.35	3.00	3.10	2.75
5	2.55	3.75	4.10	3.70	3.25	2.95	3.05	2.75
6	2.55	3.85	4.10	3.60	3.20	2.90	3.00	2.70
7	2.55	3.95	4.30	3.65	3.20	2.90	3.20	2.65
8	2.60	4.10	4.45	3.90	3.20	3.15	3.10	2.50
9	2.65	4.00	4.65	3.85	3.15	3.10	3.15	2.50
10	2.80	4.10	4.65	3.80	3.10	3.00	3.15	2.55
11	2.75	4.00	4.40	3.85	3.10	3.00	3.10	2.65
12	2.70	4.00	4.45	3.80	3.00	3.00	3.10	2.70
13	2.80	4.10	4.50	3.80	3.00	3.05	3.10	2.70
14	2.90	4.15	4.55	3.80	3.00	3.45	3.05	2.75
15	3.05	4.10	4.65	3.75	3.05	3.35	3.05	2.75
16	3.25	4.15	4.70	3.70	3.05	3.30	3.15	2.60
17	3.35	4.05	4.40	3.65	3.00	3.20	3.15	2.55
18	3.60	4.20	4.40	3.60	3.00	3.15	3.00	2.60
19	3.55	4.20	4.40	3.55	3.00	3.10	3.05	2.55
20	3.55	4.05	4.25	3.50	2.90	3.20	3.00	2.60
21	3.50	4.05	4.45	3.25	2.85	3.30	3.00	2.55
22	3.25	4.05	4.50	3.25	2.80	3.35	2.95	2.50
23	3.25	4.25	4.50	3.30	2.75	3.20	2.85	2.50
24	3.35	4.40	4.45	3.45	2.75	3.20	2.80	2.50
25	3.55	4.50	4.45	3.45	2.80	3.25	2.95	2.50
26	3.70	4.65	4.50	3.45	2.80	3.25	2.85	2.40
27	3.80	4.65	4.20	3.40	2.80	3.20	2.85	2.40
28	3.65	4.40	3.95	3.30	2.80	3.25	2.75	2.45
29	3.60	4.60	4.00	3.30	2.80	3.30	2.75	2.40
30	3.55	4.55	4.05	3.30	2.80	3.30	2.80	2.35
31	.....	4.50	.....	3.35	2.75	.....	2.85	.....

DOLORES STATION ON DOLORES RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 261, is located about one-half mile above the railroad depot at Dolores, Colorado. The gage consists of a vertical 2 by 6 inch plank, bolted to the abutment of a footbridge, on the left side of the river. The bench mark consists of a nail driven in the base of a cottonwood tree 18 feet southwesterly from the gage, and it is 15.60 feet above datum. The observer is Mrs. Mary D. Smith. The following discharge measurements were made in 1897 by F. Cogswell:

April 21, gage height, 5.10 feet; discharge, 2,133 second-feet.
May 12, gage height, 5.15 feet; discharge, 2,216 second-feet.
June 23, gage height, 4.20 feet; discharge, 1,089 second-feet.
July 21, gage height, 3.00 feet; discharge, 273 second-feet.
August 25, gage height, 2.65 feet; discharge, 92 second-feet.
September 22, gage height, 3.32 feet; discharge, 404 second-feet.
October 20, gage height, 3.25 feet; discharge, 330 second-feet.

Daily gage height, in feet, of Dolores River at Dolores, Colorado, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	3.00	5.15	5.55	3.60	2.90	2.60	3.35	3.00
2	3.00	5.40	5.40	3.55	2.90	2.60	3.50	3.00
3	3.05	5.45	4.85	3.55	3.00	2.85	3.50	3.00
4	3.25	5.35	4.75	3.55	3.00	2.80	3.55	3.00
5	3.35	5.45	4.80	3.40	3.00	3.80	3.40	3.00
6	3.35	5.45	4.75	3.40	2.95	3.80	3.30	2.90
7	3.35	5.50	4.85	3.40	2.90	3.80	3.30	2.90
8	3.35	5.60	4.95	3.40	2.90	3.90	3.45	2.85
9	3.50	5.85	4.80	3.50	2.90	3.25	3.55	2.85
10	3.75	5.60	5.15	3.40	2.90	3.15	3.45	3.05
11	4.10	5.40	4.85	3.30	2.85	3.05	3.40	2.95
12	4.15	5.20	5.35	3.30	2.80	3.20	3.30	2.95
13	4.45	5.45	4.65	3.30	2.80	3.20	3.30	2.90
14	4.70	5.50	4.80	3.20	2.80	3.35	3.30	2.90
15	5.05	5.45	4.80	3.20	2.80	3.25	3.30	2.85
16	5.15	5.20	4.75	3.30	2.80	3.15	3.30	2.80
17	5.40	5.10	4.50	3.30	2.80	3.10	3.30	2.80
18	5.95	5.35	4.40	3.20	2.80	3.00	3.30	2.80
19	5.85	5.55	4.25	3.15	2.70	2.95	3.30	2.80
20	5.40	5.75	4.25	3.00	2.70	3.10	3.20	2.80
21	5.15	5.65	4.25	3.00	2.70	3.40	3.20	2.80
22	4.85	5.40	4.25	3.00	2.70	3.40	3.20	2.80
23	4.75	5.40	4.20	3.20	2.70	3.20	3.20	2.80
24	4.70	5.70	4.05	3.10	2.70	3.25	3.20	2.80
25	5.15	5.80	3.95	3.10	2.70	3.40	3.20	2.80
26	5.50	5.65	3.95	3.05	2.70	3.45	3.10	2.80
27	5.80	5.75	3.80	3.00	2.70	3.45	3.10	2.80
28	5.05	5.05	3.70	3.00	2.70	3.35	3.10	2.70
29	5.20	5.35	3.65	2.95	2.70	3.45	3.00	2.70
30	5.15	5.60	3.55	2.95	2.70	3.40	3.00	2.70
31	.....	5.45	.....	2.90	2.60	.....	3.00	.....

ARBOLES STATION ON SAN JUAN RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 279, is located at a foot bridge about 1,000 feet below the Denver and Rio Grande Railroad depot at Arboles, Colorado, and is above the mouth of the Piedra River. The gage consists of two inclined 4 by 4 inch timbers marked to vertical tenths of a foot, the space between marks being 0.131 of a foot, and it is bolted to the rocky bank on the right-hand side of the river. The left bank is low and liable to overflow, the right is high and rocky; the current is sluggish, and the bed sandy and shifting. Discharge measurements are made during high water at the footbridge, and at low stages about 1,300 feet below the gage, where the bed of the stream is composed of small stones and is less liable to change, and the current is swift. The observer is T. F. Burke, section foreman. The following discharge measurements have been made in 1897 by F. Cogswell:

April 25, gage height, 8.30 feet; discharge, 2,753 second-feet.
May 16, gage height, 8.80 feet; discharge, 3,316 second feet.
June 27, gage height, 7.60 feet; discharge, 1,604 second-feet.
July 25, gage height, 6.50 feet; discharge, 446 second-feet.
August 29, gage height, 5.80 feet; discharge, 209 second-feet.
September 26, gage height, 8.00 feet; discharge 2,048 second-feet.
October 24, gage height, 6.90 feet; discharge, 795 second-feet.

Daily gage height, in feet, of San Juan River at Arboles, Colorado, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	6.50	8.20	9.10	7.25	6.20	5.70	6.50	6.60
2	6.80	8.40	8.85	7.30	6.20	5.70	6.50	6.50
3	6.60	8.45	8.35	7.45	6.30	6.50	6.65	6.50
4	6.75	8.60	8.10	7.40	6.30	5.90	7.50	6.50
5	6.95	9.05	8.05	7.10	6.35	6.00	7.35	6.50
6	7.45	8.50	8.10	7.05	6.25	6.65	7.10	6.50
7	7.85	8.63	8.25	6.90	6.20	7.00	7.05	6.50
8	7.25	8.70	8.50	6.95	6.20	6.40	7.15	6.40
9	7.20	8.85	8.50	7.05	6.20	6.80	8.05	6.40
10	7.25	8.90	8.60	7.10	6.30	6.50	7.90	6.40
11	7.85	8.55	8.75	7.05	6.20	6.45	7.70	6.40
12	7.65	8.50	8.50	6.90	6.10	7.90	7.55	6.40
13	7.75	8.70	8.40	6.90	6.10	6.95	7.40	6.40
14	7.80	8.75	8.40	6.70	6.15	7.15	7.20	6.35
15	8.10	8.60	8.35	6.70	6.10	6.65	7.50	6.30
16	8.20	8.75	8.40	6.70	6.15	6.50	7.50	6.30
17	8.60	8.65	8.15	6.70	6.35	6.40	7.50	6.30
18	8.90	8.85	7.85	6.75	6.15	6.40	7.40	6.30
19	8.90	9.20	7.80	6.60	6.10	6.30	7.35	6.20
20	8.50	9.55	7.90	6.60	6.05	6.30	7.20	6.20
21	8.45	9.05	7.85	6.50	6.00	6.60	7.05	6.20
22	8.10	8.75	7.95	6.50	6.00	6.45	6.95	6.20
23	7.70	8.95	7.95	6.75	6.00	6.40	6.90	6.20
24	7.85	9.20	7.75	6.65	6.00	6.40	6.90	6.20
25	8.15	9.20	7.60	6.50	5.90	7.10	6.85	6.20
26	8.35	9.30	7.70	6.40	5.90	7.65	6.80	6.20
27	8.75	9.35	7.65	6.40	5.90	7.05	6.80	6.20
28	8.20	9.05	7.55	6.30	5.90	6.90	6.70	6.15
29	8.10	9.10	7.40	6.30	5.80	6.70	6.70	6.10
30	8.10	9.00	7.20	6.25	5.80	6.55	6.60	6.10
31	.....	9.05	.....	6.20	5.70	.....	6.60	.....

ARBOLES STATION ON PIEDRA RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 281, is located at the railroad bridge across the Piedra River, about one-half mile from the Denver and Rio Grande Railroad depot at Arboles, Colorado. The Piedra empties into the San Juan a short distance below this point. The gage is bolted to the stone abutment of the railroad bridge on the right-hand side of the stream, and consists of a vertical 4 by 4 inch timber. A cross cut in the top of the abutment in the southeast corner of bridge 402A is 14.88 feet above gage zero. The banks are both high, the current is swift, the bed is composed of small stones, and the cross section does not change materially. The observer is T. F. Burke. The following discharge measurements were made in 1897 by F. Cogswell:

April 24, gage height, 5.20 feet; discharge, 1,429 second-feet.
May 15, gage height, 5.65 feet; discharge, 1,629 second-feet.
June 26, gage height, 4.20 feet; discharge, 677 second-feet.
July 24, gage height, 3.10 feet; discharge, 290 second-feet.
August 28, gage height, 2.60 feet; discharge, 65 second-feet.
September 25, gage height, 4.15 feet; discharge, 675 second-feet.
October 23, gage height, 4.00 feet; discharge, 586 second-feet.

Daily gage height, in feet, of Piedra River at Arboles, Colorado, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	3.45	5.80	6.15	3.70	2.80	2.60	3.70	3.50
2	3.75	6.10	5.85	3.75	2.80	2.60	4.20	3.40
3	3.55	6.05	5.35	4.00	2.80	3.20	4.25	3.40
4	3.65	6.40	5.10	3.90	2.80	3.00	5.00	3.35
5	4.20	6.45	5.05	3.70	2.80	2.95	5.05	3.30
6	4.45	6.60	5.05	3.60	2.80	3.40	4.75	3.30
7	4.95	6.65	5.25	3.50	2.80	3.50	4.55	3.30
8	4.80	6.60	5.40	3.50	2.80	3.30	4.60	3.30
9	4.80	6.25	5.35	3.45	2.80	3.65	5.75	3.20
10	4.90	6.25	5.45	3.60	2.95	3.40	5.25	3.25
11	5.45	5.90	5.35	3.50	2.80	3.35	4.95	3.30
12	5.45	5.75	5.30	3.50	2.75	4.20	4.85	3.20
13	5.55	5.95	5.15	3.40	2.85	4.00	4.65	3.20
14	5.65	5.95	5.20	3.30	2.80	4.05	4.50	3.20
15	6.00	5.75	5.15	3.25	2.75	3.65	4.90	3.10
16	6.00	5.80	5.30	3.30	2.70	3.50	4.85	3.10
17	6.20	5.65	5.00	3.25	2.70	3.45	4.60	3.10
18	6.35	5.95	4.70	3.20	2.80	3.30	4.50	3.05
19	6.35	6.10	4.65	3.20	2.70	3.30	4.40	3.00
20	6.00	6.15	4.70	3.10	2.80	3.80	4.25	3.00
21	6.05	5.95	4.60	3.00	2.75	4.05	4.10	3.00
22	5.70	5.80	4.60	3.00	2.70	3.70	4.05	3.00
23	5.50	5.90	4.55	3.05	2.70	3.55	4.00	3.00
24	5.30	6.35	4.45	3.10	2.70	3.60	3.90	3.00
25	5.50	6.40	4.25	3.00	2.60	4.00	3.80	3.00
26	5.60	6.40	4.25	3.00	2.60	4.35	3.80	3.00
27	6.00	6.35	4.20	3.00	2.60	4.05	3.70	3.00
28	5.65	6.05	4.05	2.90	2.60	3.95	3.70	.....
29	5.70	6.15	3.90	2.90	2.60	3.80	3.65	.....
30	5.80	6.00	3.80	2.90	2.60	3.70	3.60	.....
31	.....	6.05	.....	2.90	2.60	.....	3.50	.....

DURANGO STATION ON ANIMAS RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 283, is located about 200 yards west of the railroad station at Durango, Colorado, at the wagon bridge crossing Animas River, 200 feet above the Rio Grande Southern Railroad Bridge. The observer is George Robertson, a miller at Durango. The gage is spiked to the west side of the south end of the middle pier of the wagon bridge. The head of a bolt at the east abutment of the railroad bridge is 17.24 feet above gage datum. The banks are high and rocky and the section is excellent for obtaining accurate measurements of discharge. Lightner Creek enters Animas River from the right about 100 feet below the wagon bridge and between it and the railroad bridge. The following discharge measurements were made in 1897 by F. Cogswell:

April 23, gage height, 7.75 feet; discharge, 2,176 second-feet.
May 14, gage height, 9.20 feet; discharge, 4,786 second-feet.
June 25, gage height, 7 85 feet; discharge, 2,534 second-feet.
July 23, gage height, 6.10 feet; discharge, 997 second-feet.
August 27, gage height, 5.10 feet; discharge, 328 second-feet.
September 24, gage height, 6.05 feet; discharge, 905 second-feet.
October 22, gage height, 6.50 feet; discharge, 1,121 second-feet.

Daily gage height, in feet, of Animas River at Durango, Colorado, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.10	.....	.....	5.75	8.75	9.40	7.15	5.70	5.10	6.35	5.80	5.20
2	5.20	.....	.....	5.80	8.85	8.85	7.00	5.75	5.00	6.75	5.80	5.20
3	.....	5.00	5.10	5.75	8.70	8.15	7.00	5.75	5.60	7.05	5.80	5.20
4	.....	.....	.....	6.20	8.55	7.90	6.80	5.75	5.70	7.15	5.70	5.15
5	5.20	.....	.....	6.20	8.50	8.10	6.50	5.90	5.65	7.05	5.70	.....
6	.....	4.90	5.00	7.10	8.80	8.25	6.55	5.80	5.60	6.85	5.70	5.30
7	.....	.....	.....	7.30	9.20	8.40	6.85	5.80	5.60	6.70	5.70	.....
8	.....	.....	.....	7.40	9.50	8.90	6.85	5.70	5.70	6.80	5.60	.....
9	5.00	5.00	.....	7.40	9.45	8.95	7.00	5.70	6.25	7.65	5.60	.....
10	.....	.....	5.10	7.75	9.30	9.10	6.95	5.65	5.95	7.45	5.60	.....
11	.....	.....	.....	7.80	8.90	8.60	6.85	5.60	5.95	7.25	5.60	5.10
12	5.00	.....	.....	7.55	8.70	8.50	6.75	5.60	6.55	7.15	5.60	.....
13	.....	5.10	5.00	7.75	8.95	8.55	6.55	5 60	6.55	7.05	5.50	.....
14	.....	.....	.....	8.00	9.20	8.90	6.45	5.55	6.70	6.95	5.50	5.30
15	.....	.....	.....	8.60	8.95	8.95	6.45	5.50	6.50	7.55	5.50	.....
16	4.90	5.00	.....	8.80	8.95	9.05	6.45	5.50	6.20	7.25	5.50	.....
17	.....	.....	5.10	8.95	8.60	8.45	6.35	5.50	6.00	7.05	5.50	.....
18	.....	.....	.....	9.00	9.05	8.05	6.25	5.50	5.95	6.85	5.40	5.20
19	.....	.....	.....	9.20	9.15	7.95	6.15	5.45	5.85	6.75	5.40	.....
20	5.00	4 80	5.20	8.50	9.00	8.10	6.05	5.40	5.80	6.65	5.40	.....
21	.....	.....	.....	8.30	8.70	8.30	6.00	5.40	6.30	6.55	5.40	5.30
22	.....	.....	.....	7.90	8.70	8.30	6.00	5.35	6.25	6.50	5.40	.....
23	5.30	.....	.....	7.65	9.25	8.40	6.05	5.30	6.15	6.40	5.45	.....
24	.....	5.00	5.10	7.50	9.60	8.10	6.05	5.25	6.05	6.30	5.40	5.10
25	.....	.....	.....	8.35	9.75	7.75	6.00	5.20	6.25	6.30	5.40	.....
26	.....	.....	.....	8.65	9.65	8 00	5.90	5.20	6.50	6.20	5.40	.....
27	5.00	5.10	5.50	8.90	9.55	8 05	5.90	5.10	6.40	6.10	5.35	.....
28	.....	.....	.....	8.35	8.85	7.50	5.80	5.10	6.25	6.00	5.30	5.20
29	.....	.....	.....	8.50	9.25	7.30	5.80	5.10	6.30	6.00	5.25	.....
30	5.00	.....	5.60	8.60	9.35	7.15	5 75	5.10	6.30	5.95	5.20	.....
31	.....	.....	.....	.....	9.25	.....	5.70	5.10	.....	5.90	.....	5.50

BUTTES STATION ON GILA RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 286, is located at the buttes 16 miles above Florence, Arizona. This gage is bolted to a solid rock on the right bank, where the river emerges from the lower end of the gorge. Measurements are made from a car suspended from a cable, a short distance above the gage. Owing to the shifting character of the bottom, it was necessary to make a large number of discharge measurements and the following were made by W. J. Brash and A. T. Colton in 1897:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Jan. 1	2.30	445	Feb. 26	2.60	646	May 28	1.65	94
Jan. 5	2.25	413	Mar. 2	2.50	593	June 10	1.50	72
Jan. 8	2.24	377	Mar. 5	2.52	614	June 30	1.30	20
Jan. 12	2.90	853	Mar. 9	2.60	687	July 11	3.00	726
Jan. 14	3.10	846	Mar. 12	2.48	568	July 27	1.93	173
Jan. 15	3.80	1,891	Mar. 16	2.45	585	Aug. 11	2.25	365
Jan. 16	5.30	3,895	Mar. 20	2.58	681	Aug. 14	4.70	3,181
Jan. 18	4.60	3,085	Mar. 23	2.90	1,010	Aug. 31	1.90	246
Jan. 22	3.40	1,446	Mar. 26	2.74	833	Sept. 8	6.75	5,588
Jan. 26	3.05	1,045	Mar. 31	2.78	837	Sept. 13	3.50	1,946
Jan. 29	2.85	912	Apr. 8	2.54	675	Sept. 15	5.30	4,950
Feb. 1	3.50	1,530	Apr. 14	2.70	797	Sept. 23	3.75	2,099
Feb. 5	3.20	1,123	Apr. 20	2.60	757	Sept. 28	3.70	2,068
Feb. 10	2.85	926	Apr. 28	2.43	516	Oct. 10	2.65	868
Feb. 13	2.71	840	May 6	2.22	318	Oct. 24	2.23	601
Feb. 16	2.54	700	May 14	1.96	188			
Feb. 22	2.82	808	May 20	1.80	134			

Daily gage height, in feet, of Gila River at the Buttes, Arizona, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	2.30	3.50	2.57	2.75	.....	1.60	1.30	2.40	1.80	3.40
2	2.30	3.40	2.50	2.70	2.80	1.50	1.30	2.40	1.80	2.97
3	2.26	3.30	2.52	2.68	.....	1.50	1.30	2.20	1.80	2.90
4	2.26	3.25	2.64	2.65	2.27	1.50	1.30	2.30	1.76	2.80
5	2.25	3.20	2.52	.....	.....	1.50	1.30	2.60	1.72	2.65
6	2.25	3.10	2.52	2.67	2.22	1.50	1.30	2.40	1.73	2.60
7	2.24	3.00	2.70	.....	.....	1.50	1.30	2.30	1.83	2.58
8	2.24	2.95	2.62	2.54	2.17	1.50	1.20	3.00	7.00	2.55
9	2.24	2.90	2.60	.....	.....	1.50	1.20	2.30	4.40	2.47
10	2.23	2.85	2.60	2.60	2.10	1.50	4.10	2.20	3.80	.....
11	3.28	2.80	2.50	.....	.....	1.50	3.00	2.20	4.90	.....
12	2.90	2.73	2.48	2.67	2.05	1.55	4.00	2.20	4.20	.....
13	3.87	2.71	2.48	.....	.....	1.50	3.40	5.30	3.50	.....
14	3.10	2.70	2.50	2.70	1.96	1.50	3.00	4.70	4.90	.....
15	3.45	2.62	2.40	.....	.....	1.50	2.50	4.70	5.30	.....
16	5.30	2.54	2.45	2.70	1.91	1.50	2.00	4.80	5.10	.....
17	5.60	2.50	2.46	.....	.....	1.50	2.20	2.90	4.60	.....
18	4.60	2.47	2.50	2.70	1.88	1.50	2.10	2.70	5.40	.....
19	4.10	2.45	2.53	.....	.....	1.50	3.00	2.40	4.80	.....
20	3.90	2.50	2.58	2.65	1.80	1.40	3.50	2.30	3.85	.....
21	3.70	2.95	2.71	.....	.....	1.40	2.50	2.30	4.60	.....
22	3.40	2.85	2.83	2.59	1.77	1.40	3.00	2.60	4.20	.....
23	3.30	2.80	2.90	.....	.....	1.40	3.00	2.40	3.75	.....
24	3.25	2.79	2.90	2.55	1.70	1.40	2.50	2.20	3.70	.....
25	3.15	2.65	2.90	.....	.....	1.40	2.00	2.20	3.65	.....
26	3.05	2.60	2.74	2.50	1.68	1.30	2.20	2.10	3.75	.....
27	3.00	2.58	2.72	.....	.....	1.30	2.10	2.10	3.70	.....
28	2.90	2.58	2.70	2.43	1.65	1.30	2.50	2.00	3.70	.....
29	2.85	.....	2.73	.....	.....	1.30	2.00	2.00	3.55	.....
30	3.25	.....	2.85	2.40	.....	1.30	2.00	1.90	3.25	.....
31	3.17	.....	2.78	.....	.....	.....	2.00	1.90	.....	.....

McDOWELL STATION ON SALT RIVER.

This station is located ¾ mile above the mouth of the Verde River and 35 miles northeast of Phœnix, Arizona, and was established April 20, 1897. The gage consists of 2 by 6 inch scantling, bolted to rocks on south side of river about 300 feet above the cable. The bench mark is a nail in polyverde tree about 75 feet west of north cable anchorage, and it is 17.33 feet above gage zero. The observer is B. Valasco. The following is a list of discharge measurements made in 1897 by W. A. Farish and others:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Apr. 21	13.30	4,085	May 29	10.40	715	June 30	9.55	217
Apr. 25	12.50	2,913	June 1	10.35	647	July 10	9.50	169
Apr. 28	12.10	2,290	June 3	10.30	606	July 19	9.55	198
Apr. 30	12.00	2,035	June 5	10.23	569	Aug. 15	10.10	373
May 4	11.55	1,639	June 8	10.09	476	Aug. 29	10.15	403
May 8	11.33	1,563	June 10	10.00	456	Sept. 13	11.35	733
May 11	11.20	1,385	June 12	9.95	430	Sept. 26	11.45	1,068
May 15	10.94	1,223	June 15	9.90	399	Oct. 20	10.10	393
May 18	10.73	992	June 17	9.86	379	Oct. 31	10.10	325
May 20	10.66	875	June 19	9.80	341	Nov. 21	10.00	284
May 22	10.61	852	June 22	9.74	299	Nov. 28	10.00	270
May 25	10.54	805	June 24	9.70	270	Dec. 19	10.10	264
May 27	10.45	748	June 26	9.63	244	Dec. 27	10.05	273

Daily gage height, in feet, of Salt River at McDowell, Arizona, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	11.00	10.35	9.50	9.50	10.00	11.45	10.05	10.00
2	.....	11.75	10.32	9.72	9.55	9.88	11.30	10.05	10.05
3	.....	11.62	10.29	9.52	10.55	10.40	10.90	10.05	10.10
4	.....	11.55	10.26	9.50	9.90	10.45	11.40	10.05	10.10
5	.....	11.62	10.23	9.36	10.04	10.00	10.65	10.05	10.10
6	.....	11.62	10.18	9.64	9.70	10.44	10.60	10.05	10.10
7	.....	11.48	10.12	9.66	9.88	10.60	10.70	10.05	10.10
8	.....	11.44	10.08	9.36	9.75	10.90	10.40	10.00	10.10
9	.....	11.40	10.04	9.34	9.70	10.90	10.90	10.00	10.10
10	.....	11.26	9.99	9.50	9.70	11.51	10.05	10.00	10.10
11	.....	11.20	9.96	9.50	9.82	12.73	10.04	10.00	10.10
12	.....	11.12	9.95	9.50	10.85	11.15	10.20	10.00	10.10
13	.....	11.06	9.90	9.50	10.62	11.50	10.60	10.00	10.10
14	.....	11.00	9.87	9.60	10.85	11.50	10.30	10.00	10.10
15	.....	10.94	9.90	9.76	10.10	10.60	10.30	10.00	10.10
16	.....	10.85	9.86	9.60	10.10	10.20	10.20	10.00	10.10
17	.....	10.75	9.85	9.60	10.55	10.30	10.30	10.00	10.10
18	.....	10.72	9.83	9.58	10.90	10.30	10.20	10.05	10.10
19	.....	10.68	9.79	9.55	10.50	10.03	10.30	10.00	10.10
20	13.60	10.65	9.77	9.52	10.76	10.48	10.10	10.00	10.15
21	13.30	10.62	9.75	9.43	10.30	10.25	10.25	10.00	10.15
22	13.20	10.60	9.73	9.45	10.20	10.90	9.90	10.00	10.10
23	12.90	10.58	9.70	9.45	10.20	11.00	10.00	10.00	10.10
24	12.60	10.53	9.68	9.45	10.10	11.45	10.45	10.00	10.10
25	12.50	10.53	9.65	9.42	10.00	11.50	10.50	10.00	10.10
26	12.32	10.49	9.62	9.45	10.30	11.45	10.45	10.00	10.05
27	12.15	10.44	9.60	9.45	10.60	11.70	10.45	10.00	10.05
28	12.10	10.41	9.58	9.42	10.50	12.02	10.02	10.00	10.10
29	12.10	10.40	9.56	9.75	10.00	11.90	10.90	10.00	10.10
30	12.00	10.39	9.55	9.55	10.45	11.75	10.75	10.00	10.05
31	.....	10.36	.....	9.55	10.00	.....	10.10	.....	10.05

MCDOWELL STATION ON VERDE RIVER.

This station is located ¾ mile above the mouth of Verde River, and 35 miles northeast of Phœnix, Arizona, and was established April 20, 1897. The gage consists of a 2 by 4 inch inclined rod fastened to posts driven into the east bank of the river about 400 feet below the gaging cable. The bench mark is on a catclaw tree about 100 feet southeast from the old gage on cottonwood tree, which latter is 60 feet below the cable. The elevation of the bench mark is 27.02 feet above gage datum. The observer is B. Valasco. The following is a list of discharge measurements made by W. A. Farish and others in 1897:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Apr. 21	8.85	1,328	May 29	7.74	172	July 10	7.65	183
Apr. 25	8.50	731	June 1	7.80	177	July 19	7.70	186
Apr. 28	8.37	540	June 3	7.78	174	Aug. 15	7.95	322
Apr. 30	8.32	508	June 8	7.75	176	Aug. 29	8.51	440
May 4	8.16	364	June 10	7.76	178	Sept. 13	9.35	1,949
May 8	8.12	325	June 12	7.78	159	Sept. 26	7.60	435
May 11	8.00	259	June 15	7.70	165	Oct. 21	6.70	279
May 15	7.93	236	June 17	7.63	138	Oct. 31	6.65	305
May 18	7.94	229	June 19	7.63	132	Nov. 21	6.60	246
May 20	7.85	227	June 22	7.58	128	Nov. 28	6.63	264
May 22	7.88	224	June 24	7.63	135	Dec. 19	6.75	264
May 25	7.84	205	June 26	7.55	122	Dec. 26	6.70	308
May 27	7.85	244	June 30	7.56	111			

Daily gage height, in feet, of Verde River at McDowell, Arizona, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	8.30	7.80	7.56	7.55	7.70	7.45	6.65	6.65
2	.....	8.23	7.76	7.54	7.54	7.55	7.00	6.60	6.70
3	.....	8.18	7.77	7.43	7.52	7.60	7.00	6.65	6.70
4	.....	8.16	7.77	7.42	7.52	7.85	7.40	6.65	6.70
5	.....	8.14	7.78	7.38	7.56	7.60	7.30	6.65	6.65
6	.....	8.12	7.76	7.44	7.60	7.50	7.10	6.60	6.60
7	.....	8.12	7.74	7.44	7.60	7.61	7.10	6.60	6.60
8	.....	8.12	7.75	7.40	7.65	8.80	7.20	6.60	6.60
9	.....	8.08	7.74	7.40	7.64	8.90	6.90	6.60	5.65
10	.....	8.05	7.76	7.68	7.72	8.30	7.10	6.60	6.65
11	.....	8.00	7.76	7.65	7.72	12.00	7.00	6.60	6.65
12	.....	8.00	7.78	7.88	9.00	12.00	7.10	6.65	6.65
13	.....	7.98	7.76	7.80	8.50	9.40	7.00	6.60	6.65
14	.....	7.93	7.74	7.72	8.00	9.40	7.00	6.65	6.60
15	.....	7.98	7.70	7.74	8.00	7.50	7.00	6.95	6.60
16	.....	7.93	7.66	7.70	8.00	7.50	7.00	6.60	6.60
17	.....	7.92	7.62	7.75	8.20	7.85	7.10	6.65	6.65
18	.....	7.92	7.62	7.75	8.50	7.60	7.10	6.65	6.65
19	.....	7.91	7.62	7.70	8.10	7.10	7.10	6.60	6.75
20	9.00	7.86	7.62	7.64	8.50	7.20	7.10	6.60	6.75
21	8.80	7.84	7.59	7.43	8.60	2.10	6.70	6.60	6.80
22	8 70	7.86	7.58	7.58	8.70	7.00	6.70	6.60	6.75
23	8.65	7.84	7.60	7.64	7.90	7.50	6.65	6.60	9.70
24	8.60	7.84	7.62	7.58	8.30	7.45	6.65	6.60	6.70
25	8.50	7.84	7.60	7.54	8.30	7.65	6.60	6.60	6.70
26	8.42	7.84	7.54	7.52	8.45	7.60	6.65	6.60	6.70
27	8.38	7.84	7.56	7.50	8.45	9.00	6.70	6.60	1.70
28	8.37	7.82	7.57	7.49	8.45	9.90	6.70	6.60	6.70
29	8.36	7.74	7.57	7.60	8.50	7.80	6.65	6.60	6.70
30	8.32	7.85	7.56	7.50	7.50	7.55	6.65	6.60	6.70
31	.....	7.84	.....	7.51	7.50	.....	6.65	.....	6.70

YUMA STATION ON COLORADO RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 298, is located at the bridge of the Southern Pacific Railroad Company at Yuma, Arizona, and the gage readings are maintained by that company. The gage at this point, reading from 10 to 22 feet, is nailed to the lower side of the first pier on the south bank of the river; the portion reading from 22 feet to 40 feet is nailed to a large post on the north side, east of the bridge. The figures of gage height, plus 100, indicate the elevation above sea level according to the South Pacific elevation. The channel of the river is shifting, scouring or filling with every change of river height. No discharge measurements were made in 1897.

Daily gage height, in feet, of Colorado River at Yuma, Arizona, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1....	18.58	18.33	18.33	19.42	22.42	25.17	21.50	19.25	18.58	18.92	18.75	18.42
2....	18.75	18.17	18.50	19.67	22.42	25.42	21.25	19.17	18.58	18.92	18.83	18.42
3....	18.58	18.33	18.50	19.25	22.67	25.67	20.92	19.17	18.50	18.92	19.17	18.75
4....	18.50	18.25	19.17	20.17	22.92	25.75	20.92	19.17	18.50	18.83	19.17	18.58
5....	18.42	18.42	19.33	20.00	23.00	25.83	20.92	19.00	18.58	19.17	18.92	18.42
6....	18.33	18.50	19.08	20.42	22.92	25.83	20.92	18.92	18.50	19.17	18.75	18.58
7....	18.25	18.50	19.75	20.42	23.00	25.92	20.58	18.83	18.42	18.92	18.75	18.58
8....	18.17	18.50	19.42	20.67	23.42	26.00	20.42	18.83	18.25	18.75	18.75	18.42
9....	18.00	18.42	19.00	21.00	23.75	26.08	20.42	18.67	18.25	18.42	18.67	18.42
10....	18.00	18.17	19.50	21.42	24.00	26.00	20.25	18.75	18.17	18.50	18.67	18.33
11....	18.00	18.00	20.33	21.42	24.33	25.83	20.33	18.75	18.08	18.83	18.67	18.25
12....	17.92	17.92	19.75	21.00	24.58	25.33	20.50	18.58	18.42	19.25	18.58	18.25
13....	18.33	18.17	19.58	21.42	24.83	24.75	20.58	18.83	18.17	21.00	18.58	18.08
14....	19.00	18.25	19.33	21.50	24.92	24.00	20.25	18.75	18.67	20.75	18.50	18.08
15....	20.92	18.25	19.17	21.50	25.08	23.58	20.08	19.00	18.75	21.50	18.58	18.08
16....	21.42	18.25	19.00	21.42	25.25	23.33	20.25	18.92	18.33	21.42	18.58	18.00
17....	22.50	18.25	19.17	21.25	25.33	23.25	20.25	18.92	18.25	20.92	18.58	18.00
18....	22.83	18.17	19.50	21.25	25.42	23.17	20.33	19.00	19.33	20.17	18.58	18.00
19....	21.92	18.17	19.25	21.42	25.50	23.08	20.33	19.08	19.83	19.92	18.58	18.00
20....	20.00	18.17	19.17	21.42	25.50	23.25	20.25	19.17	20.25	19.67	18.50	18.00
21....	19.42	18.17	19.00	21.42	25.42	23.25	20.00	19.08	20.75	19.58	18.42	17.92
22....	19.75	18.17	18.92	21.92	25.25	23.42	19.75	19.08	20.75	19.42	18.42	18.00
23....	19.42	18.17	18.92	22.42	25.08	23.25	19.50	18.92	19.83	19.92	18.42	18.17
24....	19.00	18.00	18.92	22.75	25.00	22.75	19.50	18.83	19.50	19.50	18.33	18.25
25....	18.83	18.00	18.75	23.00	25.00	22.33	19.42	18.75	19.50	19.33	18.33	18.08
26....	18.75	18.42	19.33	23.17	25.17	22.17	19.42	19.25	19.25	19.25	18.42	18.08
27....	18.67	18.42	19.17	23.00	25.25	21.75	19.42	18.75	19.00	19.00	18.50	18.08
28....	18.67	18.33	19.17	22.83	25.42	21.67	19.33	18.67	18.83	19.00	18.50	18.08
29....	18.67	.....	18.92	22.50	25.42	21.67	19.33	18.75	19.08	19.00	18.50	18.08
30....	18.50	.....	18.92	22.42	25.33	21.67	19.33	18.75	18.92	18.83	18.42	18.08
31....	18.42	.....	19.33	.....	25.25	.....	19.25	18.75	.....	18.75	.....	18.00

ELKO STATION ON HUMBOLDT RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 299, is located at a point 1 mile southwest of the town of Elko, Nevada. The gage is inclined, fastened to iron bolts driven into the solid rock, and placed on the left bank immediately below the bridge. The bench mark is on the southwest corner of the cofferdam surrounding a stone pier of the bridge, 80 feet north of the gage, and is at an elevation of 7.5 feet above zero on the gage. The channel is straight both above and below this point; the right bank is quite low, but the left is high and rocky. The bed of the stream is of gravel and sand, shifting slightly. The observer is John Garrecht. The following discharge measurements were made in 1897 by L. H. Taylor:

March 23, gage height, 2.80 feet; discharge, 140 second-feet.
April 9, gage height, 6.20 feet; discharge, 1,276 second-feet.
May 6, gage height, 7.20 feet; discharge, 1,778 second-feet.
June 22, gage height, 4.93 feet; discharge, 773 second-feet.
July 10, gage height, 3.30 feet; discharge, 256 second-feet.
July 26, gage height, 2.45 feet; discharge, 88 second-feet.
September 6, gage height, 1.80 feet; discharge, 6 second-feet.
November 30, gage height, 2.20 feet; discharge, 44 second-feet.

Daily gage height, in feet, of Humboldt River at Elko, Nevada, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.50	2.45	2.65	5.90	6.80	7.60	4.15	2.20	1.85	1.75	2.10	2.35
2	2.55	2.45	2.80	4.80	6.80	7.45	4.15	2.15	1.85	1.75	2.10	2.35
3	2.45	2.45	2.80	4.30	6.90	7.30	4.00	2.15	1.85	1.75	2.15	2.40
4	2.50	2.50	2.85	4.40	7.50	7.20	3.95	2.10	1.85	1.75	2.15	2.45
5	2.50	2.65	2.80	4.50	7.90	7.15	3.90	2.10	1.85	1.80	2.15	2.50
6	2.50	2.70	2.80	4.60	7.90	6.80	3.80	2.00	1.80	1.80	2.20	2.45
7	2.50	2.72	2.80	5.00	7.90	6.50	3.70	2.00	1.80	1.85	2.20	2.50
8	2.55	2.90	2.70	5.50	7.70	6.40	3.60	2.05	1.80	1.90	2.25	2.50
9	2.50	2.93	2.70	6.30	7.55	6.15	3.40	2.00	1.80	1.90	2.25	2.60
10	2.50	2.95	2.80	6.40	7.50	5.95	3.35	2.00	1.80	2.00	2.25	2.80
11	2.40	3.00	2.85	6.60	7.50	5.85	3.25	2.00	1.83	1.95	2.25	2.80
12	2.50	2.95	2.80	6.80	7.55	5.80	3.15	2.00	1.80	1.95	2.25	2.70
13	2.40	2.85	2.70	7.20	7.50	5.75	3.00	1.95	1.80	1.95	2.20	2.50
14	2.40	2.70	2.70	7.40	7.10	5.60	2.95	1.95	1.80	2.00	2.25	2.30
15	2.30	2.70	2.70	7.40	7.20	5.40	2.93	1.95	1.80	2.00	2.25	2.20
16	2.40	2.65	2.75	7.20	6.90	5.40	2.90	1.95	1.80	2.00	2.30	2.40
17	2.40	2.70	2.85	7.30	6.80	5.43	2.90	1.95	1.80	2.00	2.30	2.60
18	2.30	2.45	2.95	7.30	6.80	5.55	2.80	1.90	1.80	2.00	2.30	2.60
19	2.40	2.60	3.00	7.40	7.00	5.70	2.80	1.85	1.80	2.00	2.30	2.60
20	2.40	2.70	3.00	7.90	7.30	5.60	2.70	1.85	1.80	2.05	2.30	2.60
21	2.37	2.70	3.00	8.10	7.35	5.30	2.70	1.85	1.80	2.05	2.30	2.60
22	2.35	2.60	2.80	8.20	7.55	5.00	2.65	1.85	1.80	2.10	2.30	2.50
23	2.30	2.50	2.90	8.20	7.70	4.85	2.60	1.87	1.80	2.05	2.35	2.60
24	2.37	2.50	3.00	7.80	8.00	4.50	2.60	1.87	1.80	2.05	2.40	2.65
25	2.40	2.40	3.60	7.50	8.25	4.50	2.55	1.87	1.80	2.05	2.35	2.50
26	2.40	2.50	3.90	7.20	8.30	4.20	2.50	1.87	1.80	2.00	2.35	2.45
27	2.42	2.60	4.30	6.90	8.40	4.15	2.40	1.87	1.77	2.10	2.35	2.50
28	2.40	2.70	5.30	6.00	8.45	4.15	2.35	1.87	1.77	2.15	2.30	2.40
29	2.40	.....	7.30	6.70	8.35	4.30	2.20	1.87	1.77	2.05	2.25	2.40
30	2.42	.....	6.90	6.70	8.10	4.25	2.30	1.85	1.75	2.05	2.30	2.40
31	2.40	.....	6.10	.....	7.90	.....	2.25	1.85	.....	2.10	.....	2.40

BATTLE MOUNTAIN STATION ON HUMBOLDT RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 302, is located at the county highway bridge, three-fourths of a mile northeast of the town of Battle Mountain, Nevada. C. R. Taylor is the observer. The gage is vertical and is spiked to the timber wing wall immediately above the bridge, on the left bank. The bench mark is on a spike in the tie beam at the east side of the bridge near the south end, at an elevation of 10 feet above zero on the gage. The channel is curved at this point and the banks are low and liable to overflow at high water. There are also several sloughs or side channels, so at extreme high water it is difficult to obtain an accurate measurement of the flow of the stream. The bed of the stream is of sand and gravel and shifts considerably. The following discharge measurements were made in 1897 by L. H. Taylor:

March 17, gage height, 2.85 feet; discharge, 276 second-feet.
April 4, gage height, 6.10 feet; discharge, 944 second-feet.
April 10, gage height, 7.10 feet; discharge, 1,557 second-feet.
April 15, gage height, 8.30 feet; discharge, 2,454 second-feet.
May 26, gage height, 8.60 feet; discharge, 2,870 second-feet.
June 24, gage height, 6.70 feet; discharge, 1,394 second-feet.
July 6, gage height, 4.70 feet; discharge, 711 second-feet.
July 21, gage height, 2.55 feet; discharge, 306 second-feet.
August 20, gage height, 0.85 foot; discharge, 16 second-feet.
September 23, gage height, 0.45 foot; discharge, 4 second-feet.

Daily gage height, in feet, of Humboldt River at Battle Mountain, Nevada, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.20	2.30	2.45	5.80	8.58	8.76	5.25	1.60	0.60	0.55	1.55	2.00
2	2.20	2.30	2.45	6.60	8.58	8.80	5.10	1.50	.55	.55	1.55	2.00
3	2.25	2.30	2.40	6.90	8.57	8.76	5.00	1.45	.50	.55	1.60	2.00
4	2.25	2.35	2.40	6.10	8.56	8.73	4.90	1.40	.50	.60	1.60	2.05
5	2.25	2.35	2.50	6.10	8.56	8.70	4.80	1.30	.50	.60	1.60	2.05
6	2.15	2.20	2.50	6.15	8.55	8.66	4.70	1.25	.50	.65	1.65	2.05
7	2.15	2.35	2.50	6.30	8.54	8.60	4.60	1.20	.50	.65	1.65	2.00
8	2.10	2.30	2.70	6.50	8.55	8.56	4.50	1.20	.50	.75	1.65	2.10
9	2.10	2.30	2.85	6.90	8.56	8.45	4.40	1.15	.50	1.20	1.65	2.10
10	2.20	2.35	2.60	7.20	8.57	8.30	4.20	1.15	.50	1.20	1.65	2.10
11	2.20	2.35	2.45	7.60	8.58	8.10	4.00	1.10	.50	1.00	1.70	2.20
12	2.20	2.35	2.45	7.90	8.59	7.95	3.85	1.10	.50	.90	1.70	2.35
13	2.20	2.35	2.50	8.10	8.60	7.80	3.75	1.05	.50	.90	1.70	2.40
14	2.20	2.35	2.60	8.25	8.55	7.70	3.40	1.05	.50	.90	1.70	2.40
15	2.20	2.40	2.70	8.35	8.54	7.65	3.20	1.05	.50	.95	1.70	2.50
16	2.20	2.40	2.80	8.42	8.54	7.60	3.40	1.00	.50	.95	1.70	2.80
17	2.10	2.45	2.85	8.47	8.52	7.55	4.80	1.00	.50	1.00	1.70	2.70
18	2.10	2.50	2.90	8.50	8.50	7.50	2.90	.95	.45	1.00	1.75	2.70
19	2.20	2.45	2.90	8.55	8.47	7.45	2.75	.90	.45	1.10	1.75	2.70
20	2.15	2.45	2.90	8.60	8.45	7.30	2.65	.90	.45	1.10	1.75	2.50
21	2.15	2.40	2.65	8.63	8.47	7.15	2.55	.85	.45	1.15	1.75	2.55
22	2.10	2.40	2.30	8.67	8.50	7.00	2.40	.85	.45	1.20	1.80	2.70
23	2.00	2.40	3.00	8.70	8.52	6.85	2.30	.80	.45	1.25	1.80	2.70
24	2.00	2.35	2.80	8.73	8.55	6.70	2.20	.80	.45	1.30	1.80	2.70
25	2.10	2.35	3.00	8.70	8.58	6.40	2.10	.75	.45	1.30	1.85	2.75
26	2.10	2.35	3.10	8.70	8.60	6.20	2.00	.75	.45	1.35	1.85	2.75
27	2.15	2.35	2.90	8.68	8.62	6.00	2.00	.70	.50	1.40	1.90	2.75
28	2.15	2.40	3.00	8.65	8.65	5.80	1.90	.70	.50	1.40	1.95	2.75
29	2.20	.....	3.30	8.63	8.68	5.60	1.85	.65	.50	1.45	1.90	2.80
30	2.20	.....	3.70	8.60	8.70	5.40	1.75	.65	.50	1.50	1.95	2.80
31	2.20	.....	5.00	.....	8.73	.....	1.70	.60	.....	1.50	.....	2.90

GOLCONDA STATION ON HUMBOLDT RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 303, is located 1¼ miles northerly from the town of Golconda, Nevada. The observer is L. Dutertre, a farmer and merchant. The gage is vertical and is spiked to posts driven into the left bank of the river. There are two bench marks, one on a 2 by 4 inch post driven flush with the ground surface 20 feet from the gage, and the other on a large spike driven into a post which is firmly set about 15 feet from the gage. The first is at an elevation of 10.55 feet and the second 13.70 feet above zero on the gage. Measurements are made from a cable and suspended car. The channel is nearly straight for about 400 feet. The banks are moderately high, but liable to overflow at extreme flood stages, perhaps once in four or five years. The bed of the stream is of gravel and sand, shifting somewhat. The following discharge measurements were made in 1897 by L. H. Taylor:

March 24, gage height, 2.80 feet; discharge, 207 second-feet.
April 9, gage height, 5.30 feet; discharge, 650 second-feet.
April 21, gage height, 7.05 feet; discharge, 1,363 second-feet.
June 2, gage height, 9.20 feet; discharge, 2,608 second-feet.
June 27, gage height, 6.87 feet; discharge, 1,198 second-feet.
July 5, gage height, 5.65 feet; discharge, 796 second-feet.
July 30, gage height, 2.90 feet; discharge, 251 second-feet.
August 10, gage height, 1.94 feet; discharge, 124 second-feet.
September 13, gage height, 0.70 foot; discharge, 7 second-feet.
November 2, gage height, 1.20 feet; discharge, 43 second-feet.
November 27, gage height, 1.75 feet; discharge, 89 second-feet.

Daily gage height, in feet, of Humboldt River at Golconda, Nevada, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.20	2.50	2.85	3.80	9.95	9.20	6.20	2.70	1.10	0.50	1.10	2.00
2	2.20	2.40	2.90	4.40	9.95	9.25	5.90	2.60	1.00	.50	1.20	2.00
3	2.20	2.45	2.90	4.80	10.00	9.25	5.90	2.50	1.00	.50	1.25	2.00
4	2.20	2.50	2.95	5.00	9.90	9.30	5.70	2.40	1.00	.50	1.30	2.00
5	2.20	2.65	2.85	5.10	9.90	9.40	5.60	2.30	1.00	.50	1.40	2.00
6	2.20	2.60	2.80	5.40	9.80	9.50	5.50	2.25	1.00	.50	1.45	2.10
7	2.20	2.50	2.80	5.40	9.75	9.55	5.35	2.20	.95	.50	1.50	2.10
8	2.20	2.50	2.85	5.40	9.70	9.65	5.20	2.15	.90	1.80	1.50	2.20
9	2.20	2.60	2.90	5.30	9.60	9.75	5.15	2.10	.85	1.50	1.50	2.30
10	2.20	2.60	2.90	5.40	9.55	9.65	4.95	1.95	.80	1.30	1.55	2.40
11	2.20	2.65	3.20	5.50	9.50	9.55	4.90	1.85	.80	1.30	1.55	2.45
12	2.20	2.70	2.10	5.70	9.50	9.40	4.85	1.80	.75	1.20	1.55	2.50
13	2.25	2.70	2.00	5.75	9.50	9.40	5.85	1.75	.70	1.20	1.55	2.50
14	2.30	2.70	2.90	5.80	9.50	9.20	4.80	1.70	.70	1.10	1.60	2.50
15	2.30	2.80	2.90	5.90	9.50	9.00	4.60	1.65	.70	1.00	1.60	2.60
16	2.30	2.90	2.90	6.10	9.50	8.80	4.40	1.65	.70	.90	1.65	2.60
17	2.30	3.00	2.90	6.40	9.50	8.60	4.20	1.60	.70	.80	1.65	2.65
18	2.80	3.00	2.80	6.50	9.50	8.40	4.00	1.55	.70	.80	1.65	2.65
19	2.25	2.90	2.85	6.80	9.50	8.10	3.90	1.50	.70	.80	1.65	2.65
20	2.25	2.85	2.90	6.90	9.50	7.80	3.80	1.45	.70	.75	1.70	2.55
21	2.30	2.95	2.95	7.00	9.50	7.70	3.75	1.40	.65	.80	1.70	2.60
22	2.20	2.85	2.95	7.40	9.50	7.60	3.60	1.30	.65	.80	1.75	2.65
23	2.10	2.80	2.95	7.60	9.45	7.40	3.50	1.30	.65	.80	1.75	2.65
24	2.15	2.70	2.90	8.00	9.40	7.20	3.40	1.35	.60	.80	1.85	2.65
25	2.20	2.70	3.00	8.10	9.30	7.20	3.45	1.40	.60	.80	1.90	2.70
26	2.30	2.75	3.50	8.50	9.30	7.00	3.30	1.40	.60	.85	1.95	2.70
27	2.80	2.90	3.50	8.80	9.30	6.90	3.20	1.35	.60	.95	1.90	2.70
28	2.70	2.80	3.10	9.15	9.25	6.70	3.10	1.35	.55	.95	1.90	2.70
29	2.40	.....	3.10	9.50	9.20	6.60	3.00	1.30	.55	.90	1.90	2.70
30	2.30	.....	3.30	9.80	9.10	6.40	2.90	1.25	.55	1.00	1.95	2.70
31	2.35	.....	3.50	.....	9.15	.....	2.80	1.20	.....	1.00	.....	2.75

OREANA STATION ON HUMBOLDT RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 306, is located at the old Oreana highway bridge, about 12 miles northeast of Lovelocks, Nevada. The observer is Joe Rodgers, section foreman of the Central Pacific Railroad. The bridge abutment to which the gage was fastened was undermined and fell May 26, 1897. A temporary gage was used until September 8, 1897, when a new inclined one was placed on the left bank of the river about a mile and a half above the site of the old gage and opposite the section house. It is made of a 2 by 4 inch pine timber spiked to posts driven well into the bank. The bench mark is a 10 by 10 inch post near the left bank of the river about 40 feet below the gage, and its elevation is 10.0 feet above the zero. The channel here is straight for about 500 feet above the gage and for about 150 feet below. The station is provided with a cable and car. The river banks are high and not liable to overflow. The bed of the stream is sandy and shifting. The following measurements were made in 1897 by L. H. Taylor:

March 25, gage height, 3.85 feet; discharge, 203 second-feet.
April 22, gage height, 6.70 feet; discharge, 1,037 second-feet.
April 30, gage height, 9.35 feet; discharge, 1,939 second-feet.
May 14, gage height, 11.70 feet; discharge, 2,932 second-feet.
June 26, gage height, 8.75 feet; discharge, 1,910 second-feet.
July 9, gage height, 6.80 feet; discharge, 1,169 second-feet.
July 22, gage height, 5.00 feet; discharge, 625 second-feet.
September 9, gage height, 2.50 feet; discharge, 59 second-feet.
November 7, gage height, 2.10 feet; discharge, 25 second-feet.

Daily gage height, in feet, of Humboldt River at Oreana, Nevada, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.80	3.30	3.80	4.50	9.80	10.60	8.10	4.20	2.60	2.30	2.05	2.45
2	2.80	3.30	3.80	4.60	9.90	10.40	7.85	4.10	2.55	2.30	2.05	2.50
3	2.80	3.20	3.90	4.60	10.30	10.30	7.60	4.10	2.55	2.30	2.05	2.55
4	2.80	3.30	3.80	4.70	10.50	10.20	7.40	4.10	2.55	2.30	2.10	2.60
5	2.90	3.40	3.80	4.80	10.80	10.10	7.20	4.00	2.55	2.30	2.10	3.10
6	2.90	3.40	3.80	4.90	11.00	10.10	7.10	3.90	2.50	2.25	2.10	3.00
7	2.90	3.40	3.80	5.00	11.20	10.10	7.00	3.90	2.50	2.35	2.10	2.90
8	2.90	3.40	3.80	5.10	11.40	10.00	6.95	3.80	2.50	2.50	2.10	2.95
9	2.95	3.50	3.85	5.20	11.70	9.90	6.80	3.80	2.50	2.40	2.15	2.70
10	2.90	3.50	3.80	5.20	11.80	9.90	6.60	3.70	2.50	2.35	2.15	2.70
11	2.90	3.40	3.90	5.20	11.90	9.80	6.40	3.60	2.45	2.30	2.15	2.75
12	2.90	3.40	3.90	5.30	12.00	9.80	6.30	3.50	2.45	2.30	2.15	2.75
13	3.00	3.50	3.85	5.40	11.90	9.80	6.10	3.40	2.45	2.30	2.20	2.80
14	3.00	3.50	3.80	5.40	11.75	9.80	6.00	3.40	2.45	2.30	2.20	2.80
15	3.00	3.50	3.80	5.60	11.80	9.80	5.90	3.30	2.45	2.25	2.20	2.80
16	3.00	3.50	3.90	5.80	11.60	9.80	5.80	3.20	2.45	2.25	2.25	2.80
17	3.10	3.50	3.80	5.80	11.40	9.80	5.60	3.10	2.40	2.25	2.25	2.85
18	3.10	3.50	3.85	5.90	11.20	9.70	5.50	3.10	2.40	2.20	2.25	2.85
19	3.10	3.60	3.80	6.00	11.00	9.70	5.40	3.10	2.40	2.20	2.25	2.85
20	3.10	3.60	3.80	6.40	11.00	9.60	5.20	3.10	2.40	2.20	2.30	2.80
21	3.10	3.60	3.80	6.50	10.90	9.40	5.10	3.10	2.40	2.20	2.30	2.90
22	3.20	3.60	3.80	6.80	10.90	9.30	5.00	3.00	2.40	2.15	2.30	2.90
23	3.20	3.70	3.80	7.10	10.90	9.00	4.90	3.00	2.40	2.15	2.20	2.90
24	3.20	3.70	3.85	7.50	10.90	8.90	4.80	2.90	2.40	2.15	2.30	2.90
25	3.30	3.70	3.85	8.05	10.90	8.80	4.80	2.80	2.40	2.15	2.35	2.95
26	3.30	3.80	3.90	8.50	10.90	8.70	4.70	2.70	2.35	2.10	2.35	2.95
27	3.20	3.80	3.90	8.80	10.90	8.60	4.60	2.70	2.35	2.10	2.40	3.00
28	3.20	3.80	4.00	9.10	10.90	8.50	4.50	2.60	2.35	2.10	2.40	3.00
29	3.30	.....	4.10	9.30	10.90	8.40	4.40	2.60	2.35	2.05	2.45	3.00
30	3.40	.....	4.30	9.50	10.80	8.20	4.30	2.60	2.30	2.05	2.45	3.05
31	3.30	.....	4.45	.....	10.80	.....	4.20	2.60	.....	2.05	.....	3.05

MASON'S RANCH STATION ON SOUTH FORK OF HUMBOLDT RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 311, is located at a point on the South Fork of Humboldt River, about 10 miles southwest of the town of Elko, Nevada, and about 6 miles above its junction with the main stream. The observer is Martin Mason, a farmer. The gage is inclined and spiked to posts driven firmly into the right bank. There is one bench mark on a 2 by 4 inch post 2½ feet long driven flush with the ground 10 feet north of the gage, and having an elevation of 7.50 feet above zero on the gage. Measurements are made from a cable and suspended car at a point 1 mile above the gage, the latter being placed, for the convenience of the observer, near his farm. At the point of measurement the banks are high and the channel is straight for over 600 feet. The bed of the stream is of rock and gravel and is quite stable. The following discharge measurements were made in 1897 by L. H. Taylor:

April 6, gage height, 1.95 feet; discharge, 139 second-feet.
May 7, gage height, 5.00 feet; discharge, 1,128 second-feet.
June 9, gage height, 3.65 feet; discharge, 800 second-feet.
June 22, gage height, 2.30 feet; discharge, 363 second-feet.
July 11, gage height, 1.75 feet; discharge, 211 second-feet.
July 25, gage height, 1.20 feet; discharge, 102 second-feet.
September 24, gage height, 0.35 foot; discharge, 5 second-feet.
October 10, gage height, 0.60 foot; discharge, 19 second-feet.
November 29, gage height, 0.90 foot; discharge, 56 second-feet.

Daily gage height, in feet, of South Fork of Humboldt River at Mason's ranch, Nevada, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.20	1.20	1.30	2.20	4.00	4.25	2.05	0.90	0.30	0.40	0.80	1.00
2	1.20	1.30	1.30	1.85	4.05	3.90	2.00	.85	.30	.45	.80	1.20
3	1.25	1.25	1.20	1.80	4.15	3.70	2.25	.85	.30	.45	.80	.80
4	1.25	1.30	1.20	1.80	4.30	3.55	2.10	1.35	.30	.45	.85	.55
5	1.30	1.40	1.25	1.95	4.50	3.40	2.00	1.30	.30	.45	.85	.90
6	1.20	1.50	1.30	1.95	4.80	3.30	1.95	1.00	.30	.45	.85	1.00
7	1.20	1.40	1.25	2.10	5.00	3.30	1.90	.90	.30	.45	.85	1.10
8	1.10	1.35	1.20	2.20	4.90	3.40	1.85	.85	.30	.50	.85	1.10
9	1.00	1.30	1.20	2.20	4.55	3.65	1.80	.75	.30	.50	.85	1.00
10	.85	1.40	1.25	2.60	4.30	3.60	1.75	.70	.30	.60	.85	1.25
11	1.00	1.50	1.30	2.90	4.15	3.35	1.75	.65	.30	.60	.85	1.15
12	1.10	1.25	1.30	2.85	4.00	3.25	1.70	.65	.30	.60	.90	1.20
13	1.10	1.45	1.30	2.95	3.95	3.20	1.65	.60	.35	.60	.90	1.10
14	1.15	1.50	1.20	3.05	4.10	3.20	1.60	.60	.35	.70	.90	1.05
15	1.10	1.25	1.20	3.30	4.25	3.35	1.65	.55	.35	.80	.80	1.00
16	1.20	1.30	1.25	3.50	4.45	3.25	1.65	.50	.35	.80	.85	1.00
17	.80	1.40	1.40	3.70	4.55	3.30	1.55	.45	.35	.80	1.15	1.00
18	.75	1.40	1.35	4.20	4.70	2.90	1.50	.45	.35	.80	.90	1.00
19	1.00	1.50	1.30	4.20	4.80	2.75	1.40	.45	.35	.75	.85	.95
20	1.10	1.55	1.30	4.50	4.80	2.55	1.20	.40	.35	.75	.85	.90
21	1.10	1.40	1.35	4.40	5.20	2.45	1.10	.40	.35	.75	.90	.90
22	1.15	1.45	1.25	4.20	5.20	2.25	1.10	.40	.35	.75	.95	1.00
23	1.10	1.40	1.35	3.60	5.40	2.25	1.15	.40	.35	.80	.95	1.00
24	1.15	1.50	1.65	3.40	5.45	2.25	1.10	.35	.35	.90	.95	.90
25	1.20	1.30	2.40	3.30	5.50	2.20	1.15	.35	.35	.90	.90	.90
26	1.20	1.25	2.40	3.30	5.40	2.20	1.20	.35	.35	.85	1.50	1.00
27	.80	1.25	2.25	3.50	5.05	2.20	1.10	.35	.35	.80	1.60	1.00
28	1.20	1.30	3.20	3.75	4.75	2.10	1.05	.45	.35	.80	1.10	.90
29	1.20	.....	3.50	3.85	4.60	2.00	1.00	.35	.40	.80	.95	.90
30	1.20	.....	3.20	3.95	4.55	1.95	.95	.35	.40	.80	.90	.95
31	1.20	.....	2.70	.....	4.60	.....	.95	.30	....	.80	.....	.90

BATTLE CREEK STATION ON BEAR RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 313, is located 5 miles northwest of Preston, Idaho. The observer is John A. Nelson. The station is equipped with a cable and car. The gage consists of a vertical board nailed to a pile. The bench mark is a nail in the southeast corner of the house near the gage, about 1.5 feet from the ground, and it is 10.95 feet above the zero of the gage. The following discharge measurements were made by Samuel Fortier and others in 1897:

May 20, gage height, 5.05 feet; discharge, 5,700 second-feet.
June 17, gage height, 3.50 feet; discharge, 2,527 second-feet.
June 17, gage height, 3.50 feet; discharge, 2,969 second-feet.
July 28, gage height, 1.75 feet; discharge, 917 second-feet.
August 23, gage height, 1.57 feet; discharge, 692 second-feet.
October 29, gage height, 1.90 feet; discharge, 1,027 second-feet.

Daily gage height, in feet, of Bear River at Battle Creek, Idaho, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	1.70	.....	4.00	5.00	2.50	1.70	1.60	1.60	1.90	1.90
2	1.80	.....	.....	.....	4.10	4.90	2.50	1.70	1.60	1.90	1.90	1.90
3	.....	.....	.....	2.00	4.20	4.80	2.45	1.70	1.80	1.80	1.90	1.90
4	.....	1.70	.....	.....	4.20	4.70	2.40	1.70	1.70	1.80	1.90	1.80
5	.....	.....	.....	.....	4.30	4.70	2.40	1.70	1.60	1.80	1.90	1.70
6	1.80	1.70	1.70	.....	4.40	4.70	2.40	1.70	1.60	1.80	1.90	1.80
7	.....	.....	.....	.....	4.50	4.60	2.40	1.70	1.60	1.80	1.90	1.90
8	.....	.....	.....	.....	4.50	4.60	2.40	1.70	1.60	1.80	1.90	1.90
9	1.80	1.70	.....	.....	4.50	4.50	2.30	1.70	1.60	1.80	1.90	1.90
10	.....	.....	.....	2.50	4.50	4.40	2.20	1.70	1.60	1.80	1.90	1.80
11	.....	.....	.....	2.60	4.60	4.40	2.20	1.70	1.60	1.80	1.90	1.90
12	.....	.....	1.70	2.70	4.60	4.40	2.20	1.70	1.60	1.80	1.90	1.90
13	.....	.....	.....	2.80	4.60	4.30	2.20	1.70	1.60	2.00	1.90	1.80
14	.....	.....	.....	2.90	4.60	4.30	2.20	1.70	1.60	2.20	1.90	1.70
15	.....	.....	1.70	3.00	4.60	4.20	2.20	1.70	1.60	2.20	1.90	1.80
16	1.80	.....	.....	3.10	4.90	4.10	2.20	1.70	1.60	2.10	1.90	1.80
17	.....	.....	.....	3.20	5.00	3.50	2.10	1.70	1.60	2.00	1.90	1.70
18	.....	.....	.....	3.30	5.00	3.40	2.00	1.70	1.60	2.00	1.90	1.65
19	.....	.....	.....	3.40	5.00	3.30	2.00	1.70	1.60	2.00	1.90	1.60
20	.....	1.70	1.70	3.50	5.10	3.20	2.00	1.70	1.60	2.00	1.90	1.70
21	.....	.....	.....	3.60	5.10	3.10	2.00	1.60	1.60	2.00	2.00	1.70
22	.....	.....	.....	3.70	5.15	3.00	1.90	1.60	1.60	2.00	2.00	1.80
23	1.80	.....	.....	3.80	5.20	3.00	1.90	1.60	1.60	2.00	2.10	1.80
24	.....	.....	.....	3.90	5.15	3.00	1.80	1.60	1.60	2.00	2.10	1.80
25	.....	.....	.....	4.00	5.20	2.90	1.90	1.60	1.60	2.00	2.00	1.80
26	.....	.....	.....	4.20	5.25	2.90	1.80	1.60	1.60	2.00	2.00	1.80
27	.....	1.70	.....	4.30	5.30	2.80	1.80	1.60	1.60	2.00	2.00	1.80
28	.....	.....	.....	4.40	5.25	2.65	1.80	1.60	1.60	2.00	2.00	1.80
29	.....	.....	2.00	4.30	5.15	2.60	1.80	1.60	1.60	1.90	2.00	1.80
30	1.70	.....	.....	4.20	5.10	2.55	1.80	1.60	1.60	1.90	2.00	1.90
31	.....	.....	.....	.....	5.10	.....	1.80	1.60	.....	1.90	.....	1.90

LOGAN STATION ON LOGAN RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 316, is located in the river canyon about 2 miles east of the city of Logan, Utah. The gage is a vertical iron post set firmly into the ground and graduated to tenths of a foot. The equipment consists of a cable, car, and tag wire. The observer is J. S. Pehrson, living about one-half mile from the gage. The bench mark is a stone 35 feet northeast of the end of the cable on the north side of the river. The elevation is 14.01 feet above datum. The point of the rock and the letters "B. M." are marked with red paint. The following discharge measurements were made by Samuel Fortier and others in 1897:

May 7, gage height, 4.13 feet; discharge, 1,210 second-feet.
May 29, gage height, 4.60 feet; discharge, 1,336 second-feet.
June 17, gage height, 4.15 feet; discharge, 1,097 second-feet.
July 20, gage height, 3.20 feet; discharge, 478 second-feet.
July 26, gage height, 3.10 feet; discharge, 413 second-feet.
August 21, gage height, 2.85 feet; discharge, 305 second-feet.
August 30, gage height, 2.80 feet; discharge, 298 second-feet.
September 13, gage height, 2.80 feet; discharge, 284 second-feet.
November 12, gage height, 2.66 feet; discharge, 219 second-feet.
November 16, gage height, 2.66 feet; discharge, 219 second-feet.

Daily gage height, in feet, of Logan River at Logan, Utah, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.45	.....	.....	.....	3.80	4.75	3.50	3.05	2.80	2.80	2.70	2.65
2	.....	.....	.....	2.45	3.90	4.65	3.60	3.05	2.80	2.80	2.70	2.65
3	.....	.....	.....	.....	4.10	4.45	3.55	3.00	2.90	2.80	2.70	2.65
4	.....	.....	.....	.....	4.20	4.30	3.50	3.00	2.85	2.80	2.70	2.60
5	.....	2.45	2.40	.....	4.10	4.25	3.45	3.00	2.75	2.75	2.70	2.60
6	.....	.....	.....	.....	4.20	4.15	3.45	3.00	2.75	2.75	2.70	2.60
7	.....	.....	.....	.....	4.15	4.15	3.45	3.00	2.75	2.75	2.70	2.60
8	.....	.....	.....	.....	3.95	4.20	3.40	3.05	2.75	2.75	2.65	2.60
9	2.45	.....	.....	2.50	3.80	4.20	3.35	3.00	2.75	2.75	2.65	2.55
10	.....	.....	.....	.....	3.80	4.15	3.35	3.00	2.75	2.75	2.65	2.60
11	.....	.....	.....	.....	3.75	4.10	3.30	2.75	2.75	2.75	2.70	2.60
12	.....	2.45	2.40	.....	3.80	4.10	3.30	2.75	2.75	2.75	2.70	2.60
13	.....	.....	.....	.....	3.90	4.05	3.25	2.75	2.75	2.75	2.70	2.60
14	.....	.....	.....	.....	4.10	4.05	3.25	2.95	2.75	2.75	2.70	2.60
15	.....	.....	.....	2.75	4.15	4.05	3.25	2.95	2.75	2.75	2.65	2.55
16	2.45	.....	.....	2.80	4.20	4.10	3.25	2.95	2.75	2.75	2.65	2.55
17	.....	.....	.....	2.95	4.00	4.00	3.25	2.90	2.75	2.75	2.65	2.55
18	.....	.....	.....	3.05	4.20	3.85	3.20	2.90	2.75	2.75	2.65	2.55
19	.....	2.45	2.40	3.40	4.40	3.80	3.20	2.90	2.75	2.75	2.65	2.50
20	.....	.....	.....	3.35	4.90	3.75	3.20	2.90	2.75	2.75	2.65	2.50
21	.....	.....	.....	3.15	4.90	3.75	3.20	2.85	2.75	2.75	2.65	2.50
22	2.45	.....	.....	3.05	4.75	3.75	3.15	2.65	2.75	2.75	3.65	2.50
23	.....	.....	.....	2.95	4.80	3.75	3.15	2.85	2.75	2.75	2.65	2.50
24	.....	.....	.....	2.90	4.80	3.75	3.10	2.85	2.80	2.80	2.65	2.45
25	.....	.....	.....	3.00	4.80	3.70	3.10	2.85	2.75	2.75	2.65	2.50
26	.....	2.40	2.50	3.15	4.80	3.65	3.10	2.85	2.75	2.70	2.65	2.50
27	.....	.....	.....	3.35	4.70	3.65	3.10	2.85	2.75	2.70	2.65	2.55
28	.....	.....	.....	3.50	4.55	3.60	3.10	2.85	2.75	2.70	2.65	2.50
29	2.45	.....	.....	3.70	4.50	3.55	3.05	2.85	2.75	2.70	2.65	2.55
30	.....	.....	.....	3.75	4.55	3.55	3.05	2.80	2.75	2.70	2.65	2.55
31	.....	.....	.....	.....	4.70	.....	3.05	2.80	.....	2.70	.....	2.50

COLLINSTON STATION ON BEAR RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 319, is located in the canyon below Cache Valley, Utah, about 4 miles from the railroad station of Collinston or 2 miles east of the town of Fielding, Utah. The observer is Robert Anglesey, who is the ditch rider of the Bear River Canal and lives near the station. The gage consists of a vertical iron rod, graduated to tenths of a foot. The bench mark is a nail in an oak post 20 feet west of the gage and 20 feet north of the cable. Its elevation is 7.35 feet above the zero of the gage. The chief source of error at this station is the large rocks which are scattered over the bed. The following discharge measurements were made in 1897 by T. H. Humphreys and W. B. Dougall:

May 3, gage height, 5.95 feet; discharge, 8,344 second-feet.
May 3, gage height, 5.95 feet; discharge, 8,445 second-feet.
May 28, gage height, 6.60 feet; discharge, 10,241 second-feet.
June 19, gage height, 4.03 feet; discharge, 3,822 second-feet.
July 28, gage height, 1.80 feet; discharge, 1,274 second-feet.
August 16, gage height, 1.70 feet; discharge, 1,084 second-feet.

Daily gage height, in feet, of Bear River at Collinston, Utah, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	2.00	2.60	6.00	6.30	3.00	1.70	1.60	1.90	2.20	1.85
2	.....	2.00	.....	2.40	6.00	6.20	3.00	1.70	1.60	1.90	2.10	1.85
3	.....	.....	2.00	2.30	5.90	6.10	3.00	1.70	1.60	1.90	2.10	1.85
4	1.60	2.00	.....	2.60	6.00	6.00	2.95	1.70	1.65	1.85	2.10	1.85
5	.....	.....	2.00	3.00	6.00	5.90	2.90	1.70	1.70	1.85	2.10	1.95
6	1.80	2.00	2.00	3.40	6.20	5.80	2.85	1.70	1.80	1.90	2.00	1.95
7	.....	.....	.....	3.50	6.40	5.60	2.80	1.70	1.80	2.00	1.90	1.95
8	.....	2.10	2.00	3.60	6.50	5.40	2.65	1.70	1.80	2.10	1.80	1.95
9	2.20	.....	.....	3.80	6.60	5.20	2.55	1.70	1.80	2.15	1.80	2.05
10	.....	2.20	2.00	4.00	6.40	5.10	2.50	1.70	1.80	2.20	1.80	2.05
11	2.10	.....	.....	4.60	6.20	5.00	2.45	1.70	1.80	2.25	1.80	2.05
12	.....	2.00	.....	5.00	6.10	4.90	2.40	1.70	1.80	2.30	1.80	2.15
13	.....	2.00	2.00	4.80	6.00	4.90	2.35	1.70	1.85	2.35	1.80	2.25
14	2.20	.....	2.00	4.80	6.00	4.80	2.30	1.70	1.85	2.40	1.90	2.20
15	.....	2.00	2.00	4.80	6.00	4.60	2.20	1.70	1.85	2.45	1.90	2.25
16	2.00	.....	2.00	4.80	6.10	4.70	2.15	1.65	1.85	2.50	1.90	2.25
17	.....	2.00	2.00	4.80	6.15	4.60	2.10	1.65	1.90	2.50	1.90	2.25
18	2.00	.....	2.00	5.00	6.20	4.40	2.00	1.65	1.85	2.50	1.90	2.20
19	.....	.....	2.00	5.20	6.30	4.20	2.00	1.60	1.85	2.45	1.90	2.20
20	1.90	2.00	2.00	5.40	6.50	4.00	2.00	1.60	1.80	2.45	1.90	2.20
21	.....	.....	2.00	5.40	6.60	3.80	2.00	1.60	1.80	2.50	1.90	2.30
22	.....	2.00	2.00	5.70	6.70	3.60	2.00	1.60	1.80	2.50	1.90	2.10
23	2.00	.....	2.00	5.90	6.80	3.50	2.00	1.60	1.80	2.50	1.90	2.45
24	2.00	2.00	2.00	6.10	6.80	3.40	2.00	1.55	1.80	2.50	1.90	2.40
25	.....	.....	2.00	5.80	6.80	3.80	2.00	1.55	1.80	2.50	1.90	2.65
26	2.00	.....	2.10	5.70	6.80	3.20	2.00	1.55	1.80	2.45	1.90	2.60
27	.....	2.00	2.20	5.70	6.70	3.10	1.90	1.55	1.80	2.45	1.90	2.30
28	2.00	.....	2.20	5.80	6.70	3.05	1.85	1.50	1.85	2.40	1.85	2.20
29	.....	.....	2.60	5.90	6.60	3.00	1.80	1.50	1.85	2.35	1.90	2.15
30	2.00	.....	3.00	5.95	6.55	3.00	1.75	1.50	1.90	2.30	1.85	2.15
31	.....	.....	2.80	.....	6.40	.....	1.70	1.55	.....	2.20	.....	2.20

OGDEN STATION ON OGDEN RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 316, was located about 10 miles east of the city of Ogden, Utah, at the upper end of the canyon. Owing to the presence of the dam of the Pioneer Electric Power Company, constructed in 1896, just below this location, water was backed up and ponded around the gage. In the spring of 1897, therefore, the station was moved down the river 5 miles to near a powder mill in the canyon. The station is equipped with cable, car and tag wire. The gage is inclined and divided into tenths of a foot. The bench mark is a point on a quartzite ledge, one foot above the ground, at edge of county road, 37 feet west and 25 feet south of gage, and its elevation is 11.14 feet above the zero. The observer is Frank Hart. The following discharge measurements were made in 1897 by Samuel Fortier and W. B. Dougall.

May 11, gage height, 6.69 feet; discharge, 1,890 second-feet.
May 26, gage height, 5.79 feet; discharge, 1,423 second-feet
June 2, gage height, 4.79 feet; discharge, 682 second-feet.
June 26, gage height, 3.25 feet; discharge, 170 second-feet.
July 30, gage height, 2.80 feet; discharge, 74 second-feet.
September 15, gage height, 2.61 feet; discharge, 51 second-feet.
October 15, gage height, 2.68 feet; discharge, 78 second-feet.

Daily gage height, in feet, of Ogden River near Ogden, Utah, for 1897.

Day.	Jan.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	4.90	3.60	2.70	2.60	2.80	2.70	2.70
2	.....	.....	4.80	3.50	2.70	2.60	2.70	2.70	2.70
3	.....	.....	4.70	3.40	2.70	2.70	2.70	2.70	2.70
4	.....	.....	4.50	3.30	2.60	2.60	2.70	2.70	2.60
5	.....	.....	4.50	3.30	2.60	2.60	2.60	2.80	2.60
6	.....	.....	4.40	3.30	2.60	2.60	2.70	2.70	2.60
7	3.45	.....	4.40	3.20	2.60	2.60	2.70	2.70	2.60
8	.....	.....	4.40	3.20	2.60	2.60	2.70	2.70	2.60
9	.....	.....	4.30	3.20	2.60	2.60	2.70	2.70	2.70
10	.....	6.70	4.20	3.10	2.60	2.60	2.70	2.70	2.60
11	.....	6.70	4.10	3.00	2.60	2.60	2.70	2.70	2.60
12	.....	6.50	4.00	3.00	2.60	2.60	2.80	2.70	2.70
13	.....	6.60	3.90	3.00	2.60	2.70	2.70	2.70	2.60
14	2.80	6.80	3.90	2.90	2.60	2.60	2.80	2.70	2.60
15	.....	7.10	3.80	2.90	2.60	2.60	2.80	2.70	2.60
16	.....	6.80	4.10	2.90	2.60	2.60	2.70	2.70	2.60
17	.....	6.50	3.90	2.90	2.60	2.60	2.70	2.70	2.60
18	.....	6.40	3.90	2.90	2.60	2.60	2.70	2.70	2.50
19	.....	6.50	3.90	2.90	2.60	2.60	2.70	2.60	2.50
20	.....	7.10	3.90	2.90	2.60	2.60	2.70	2.60	2.40
21	.....	6.80	3.90	2.90	2.60	2.60	2.70	2.60	2.40
22	3.00	6.40	3.80	2.90	2.60	2.60	2.70	2.80	2.50
23	.....	6.20	3.70	2.80	2.60	2.60	2.70	2.70	2.40
24	.....	6.10	3.60	2.80	2.60	2.60	2.80	2.70	2.50
25	.....	5.90	3.50	2.80	2.60	2.60	2.70	2.80	2.40
26	.....	5.80	3.50	2.80	2.60	2.60	2.70	2.70	2.30
27	2.70	5.50	3.40	2.80	2.60	2.60	2.70	2.70	2.30
28	.....	5.20	3.40	2.70	2.60	2.60	2.70	2.70	2.60
29	.....	5.20	3.40	2.70	2.60	2.70	2.70	2.70	2.60
30	.....	5.10	3.60	2.70	2.60	2.60	2.70	2.70	2.60
31	.....	5.00	.....	2.70	2.60	.....	2.70	.....	2.60

UINTA STATION ON WEBER RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 323, is located near the watchman's house at the Union Pacific Railroad bridge, 5 miles east of Uinta, Utah. The observer is Morgan Flaherty, post-office address, Uinta, Utah. The gage consists of a horizontal timber, 4 by 4 inches by 16 feet long, fastened to two vertical posts set in the ground at the edge of the bank of the river, with one end of the timber projecting out over the water. On this horizontal timber is placed a wire gage. The bench mark consists of a spike driven into the first telegraph pole up the canyon from the gage, and its elevation is 17.44 feet above gage datum. The following discharge measurements were made in 1897 by W. B. Dougall and others:

April 29, gage height, 5.40 feet; discharge, 3,760 second-feet.
May 12, gage height, 5.25 feet; discharge, 3,662 second-feet.
May 27, gage height, 4.95 feet; discharge, 3,281 second-feet.
June 24, gage height, 2.20 feet; discharge, 805 second-feet.
July 29, gage height, 1.12 feet; discharge, 149 second-feet.
September 16, gage height, 1.40 feet; discharge, 250 second-feet.
October 15, gage height, 1.83 feet; discharge, 433 second-feet.

Daily gage height, in feet, of Weber River at Uinta, Utah, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.50	.....	.....	2.10	5.55	4.40	1.20	1.10	1.10	1.60	1.70	1.60
2	.....	1.50	1.40	2.20	5.65	4.40	1.20	1.10	1.10	1.60	1.70	1.60
3	.....	.....	.....	2.20	5.80	3.85	1.10	1.10	1.10	1.65	1.70	1.60
4	.....	.....	.....	2.45	6.10	3.55	1.20	1.10	1.10	1.80	1.70	1.60
5	1.50	1.50	1.40	2.65	6.45	3.85	1.20	1.10	1.10	1.80	1.70	1.60
6	.....	.....	.....	2.75	6.65	3.70	1.20	1.10	1.10	1.80	1.70	1.60
7	.....	.....	.....	2.75	6.90	3.45	1.20	1.10	1.20	1.80	1.70	1.60
8	.....	.....	1.60	2.70	6.75	3.05	1.20	1.10	1.20	1.80	1.70	1.60
9	1.50	1.50	.....	2.95	6.25	2.90	1.20	1.10	1.20	1.80	1.70	1.60
10	.....	.....	.....	3.50	5.65	2.90	1.20	1.10	1.20	1.80	1.70	1.60
11	.....	.....	.....	3.45	5.40	2.90	1.20	1.10	1.20	1.80	1.70	1.60
12	.....	1.50	1.60	3.65	5.30	2.75	1.20	1.10	1.20	1.80	1.70	1.60
13	.....	.....	.....	3.80	5.50	2.80	1.20	1.10	1.20	1.80	1.70	1.60
14	1.50	.....	1.50	3.85	5.80	2.70	1.20	1.10	1.20	1.80	1.70	1.60
15	.....	.....	1.50	4.05	5.90	2.55	1.20	1.10	1.20	1.80	1.70	1.60
16	.....	1.50	1.50	4.50	5.85	2.60	1.20	1.10	1.20	1.80	1.70	1.60
17	.....	.....	1.50	4.60	5.65	2.60	1.20	1.10	1.20	1.80	1.70	1.60
18	1.40	.....	1.50	4.85	5.65	2.60	1.10	1.10	1.20	1.80	1.70	1.60
19	1.40	1.50	1.50	5.30	5.65	2.60	1.10	1.10	1.30	1.80	1.70	1.60
20	.....	.....	1.50	5.70	5.85	2.45	1.10	1.10	1.30	1.80	1.70	1.60
21	.....	.....	1.60	5.35	5.75	2.30	1.10	1.10	1.30	1.80	1.60	1.60
22	.....	1.40	1.75	4.90	5.75	2.30	1.10	1.10	1.30	1.80	1.60	1.60
23	1.40	.....	1.80	4.50	5.55	2.20	1.10	1.10	1.30	1.80	1.60	1.60
24	.....	.....	1.85	4.05	5.55	2.10	1.10	1.10	1.30	1.80	1.60	1.60
25	1.50	1.40	2.10	3.85	5.50	2.10	1.10	1.10	1.30	1.80	1.60	1.60
26	.....	.....	2.50	4.10	5.25	2.10	1.10	1.10	1.35	1.80	1.60	1.45
27	.....	.....	2.70	4.70	4.95	1.90	1.10	1.10	1.40	1.80	1.60	1.50
28	.....	.....	2.75	5.15	4.45	1.65	1.10	1.10	1.40	1.80	1.60	1.45
29	1.50	.....	2.60	5.40	4.25	1.55	1.10	1.10	1.55	1.80	1.60	1.40
30	.....	.....	2.10	.....	4.45	1.45	1.10	1.10	1.60	1.80	1.60	1.40
31	.....	.....	2.10	.....	4.50	.....	1.10	1.10	.....	1.70	.....	1.40

PROVO STATION ON PROVO RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 325, is located in the canyon about 6 miles from the city of Provo, Utah. The observer is Henry V. Smith, a farmer. The gage is inclined and fastened to stakes set in the ground. The bench mark is a stone firmly bedded in a bank near the wagon road, about 100 feet southwest of the gage. It is marked "B. M." in black paint, and is 6.95 feet above the zero of the gage. The banks are medium high. The channel is straight for some distance above and below the station. The bed of the river is gravelly and the velocity is medium swift. The following discharge measurements were made in 1897 by W. B. Dougall:

May 7, gage height, 6.25 feet; discharge, 1,818 second-feet.
May 14, gage height, 6.05 feet; discharge, 1,681 second-feet.
May 24, gage height, 6.53 feet; discharge, 2,454 second-feet.
June 4, gage height, 5.35 feet; discharge, 1,167 second feet.
June 21, gage height, 4.60 feet; discharge, 564 second-feet.
August 7, gage height, 4.10 feet; discharge, 306 second-feet.
November 26, gage height, 4.40 feet; discharge, 436 second-feet.

Daily gage height, in feet, of Provo River at Provo Canyon, Utah, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	.....	5.60	5.80	4.30	4.00	4.00	4.40	4.50	4.40
2	4.40	.....	.....	.....	5.70	5.80	4.30	4.00	4.00	4.40	4.50	4.40
3	.....	.....	.....	.....	5.80	5.60	4.30	4.00	4.00	4.40	4.50	4.40
4	.....	.....	.....	4.80	5.90	5.50	4.20	4.00	4.00	4.40	4.50	4.40
5	.....	.....	.....	4.80	5.90	5.40	4.20	4.00	4.00	4.40	4.50	4.40
6	.....	4.60	4.40	4.80	6.00	5.20	4.20	4.00	4.00	4.40	4.50	4.40
7	.....	.....	.....	4.80	6.10	5.10	4.20	4.00	4.00	4.40	4.50	4.40
8	.....	.....	.....	4.80	6.10	5.10	4.20	4.00	4.00	4.40	4.50	4.30
9	4.40	.....	.....	4.80	6.20	5.10	4.20	4.00	4.00	4.40	4.50	4.30
10	.....	.....	.....	4.80	6.20	5.10	4.20	4.00	4.00	4.40	4.50	4.30
11	.....	.....	.....	5.00	5.90	5.00	4.20	4.00	4.10	4.40	4.50	4.30
12	.....	.....	.....	5.00	5.80	5.00	4.20	4.00	4.10	4.40	4.50	4.30
13	.....	4.60	4.40	5.00	6.00	5.00	4.20	4.00	4.10	4.40	4.50	4.30
14	.....	.....	.....	5.00	6.00	5.00	4.20	4.00	4.10	4.40	4.30	4.30
15	.....	.....	.....	5.00	6.20	4.90	4.20	4.00	4.10	4.40	4.30	4.30
16	.....	.....	.....	5.00	6.10	4.90	4.20	4.00	4.10	4.40	4.30	4.30
17	.....	.....	.....	5.00	6.10	4.90	4.20	4.00	4.10	4.50	4.30	4.30
18	.....	.....	.....	5.40	6.20	4.90	4.10	4.00	4.10	4.50	4.30	4.30
19	.....	4.80	.....	5.40	6.30	4.90	4.10	4.00	4.10	4.50	4.30	4.30
20	.....	4.60	4.40	5.60	6.30	4.80	4.10	4.00	4.10	4.50	4.30	4.30
21	.....	.....	.....	5.60	6.40	4.80	4.10	4.00	4.10	4.50	4.40	4.30
22	.....	.....	.....	5.40	6.50	4.60	4.10	4.00	4.10	4.50	4.40	4.30
23	4.30	.....	.....	5.00	6.50	4.50	4.10	4.00	4.10	4.50	4.40	4.30
24	.....	.....	.....	5.00	6.60	4.40	4.10	4.00	4.10	4.50	4.40	4.30
25	.....	.....	.....	5.10	6.60	4.30	4.10	4.00	4.10	4.50	4.40	4.30
26	.....	.....	.....	5.20	6.50	4.30	4.10	4.00	4.10	4.50	4.40	4.30
27	.....	4.40	.....	5.30	6.50	4.30	4.10	4.00	4.10	4.50	4.40	4.30
28	.....	.....	.....	5.40	6.40	4.30	4.10	4.00	4.20	4.50	4.40	4.30
29	.....	.....	.....	5.50	6.40	4.30	4.10	4.00	4.20	4.50	4.40	4.30
30	4.30	.....	.....	5.60	6.10	4.30	4.10	4.00	4.40	4.50	4.40	4.30
31	.....	.....	.....	.....	6.00	.....	4.10	4.00	.....	4.50	.....	4.30

GENEVA STATION ON UTAH LAKE.

This station, described in the Eighteenth Annual Report, Part IV, page 327, is located at Geneva, Utah, 3 miles south of American Fork, at the lower end of the lake. The gage consists of a vertical rod driven into the sand at the southern end of a bath-house, and nailed firmly to the floor of the house. The bench mark of the lake commissioners, a sandstone monument at the edge of the bluff and opposite the south end of the pavilion, is 18.644 feet above gage datum, which was placed 4 feet below "compromise point." The observer is John Dallin; post-office address, Pleasant Grove, Utah.

Daily gage height, in feet, of Utah Lake at Geneva, Utah, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.35	.....	1.90	1.80	.....	2.80	2.00	.....	0.80	.....	0.55	0.70
2	.....	1.55	.....	.....	.....	.....	.....	1.40	.....	.....	.....	.....
3	.....	.....	1.90	1.80	2.05	2.45	2.00	.....	.80	.....	.55	.....
4	1.35	1.58	.....	.....	.....	.....	.....	1.40	.75	0.40	.....	.75
5	.....	.....	.....	1.85	2.30	2.70	2.00	.....	.....	.....	.....	.....
6	1.40	1.68	.....	.....	.....	.....	.....	.....	.75	.40	.60	.80
7	.....	.....	.....	1.90	.....	2.70	1.90	1.30	.....	.35	.....	.....
8	1.40	1.40	.....	.....	2.40	.....	.....	.....	.70	.....	.60	.85
9	1.40	.....	.....	1.90	.....	.....	.....	1.30	.....	.40	.....	.....
10	.....	1.40	.....	.....	2.50	2.65	1.90	.....	.....	.....	.60	.....
11	1.40	.....	.....	.....	.....	.....	.....	.....	.60	.40	.....	.90
12	.....	1.40	.....	1.90	2.55	2.65	1.80	1.30	.....	.....	.....	.....
13	1.40	.....	.....	.....	.....	.....	.....	.....	.55	.35	.60	.90
14	.....	.....	.....	1.90	.....	2.40	1.75	1.20	.....	.....	.....	.....
15	1.40	1.40	.....	.....	2.60	.....	.....	.....	.50	.....	.55	.....
16	1.40	.....	.....	1.90	.....	2.40	.....	1.15	.....	.40	.....	.90
17	.....	1.45	.....	1.95	2.65	.....	1.70	.....	.....	.....	.....	.....
18	1.40	.....	.....	.....	.....	2.50	.....	1.10	.50	.45	.55	.90
19	.....	1.80	.....	2.00	2.40	.....	1.65	.....	.....	.....	.....	.....
20	1.42	1.85	.....	.....	.....	.....	.....	1.10	.50	.50	.60	.90
21	.....	.....	.....	2.00	.....	2.40	1.65	1.00	.....	.....	.....	.....
22	1.45	1.82	.....	.....	2.45	.....	.....	.....	.....	.....	.60	.95
23	1.45	.....	.....	.....	.....	2.40	.....	1.00	.40	.55	.....	.....
24	.....	1.82	.....	2.10	2.80	.....	1.55	.....	.....	.....	.....	.95
25	1.45	.....	1.70	.....	.....	.....	.....	.95	.40	.50	.....	.....
26	.....	1.88	.....	2.10	2.80	2.35	1.55	.....	.....	.....	.65	.....
27	1.45	1.88	1.75	.....	.....	.....	.....	.....	.40	.50	.70	.95
28	.....	.....	.....	2.15	.....	2.35	1.50	.90	.....	.....	.....	.....
29	.....	.....	1.80	.....	2.80	.....	.....	.....	.40	.50	.70	.95
30	1.50	.....	.....	2.20	.....	2.20	.....	.....	.40	.....	.....	1.00
31	.....	.....	1.80	.....	.....	.....	1.40	.....	.....	.....	.....	.....

POCATELLO STATION ON PORTNEUF RIVER.

This station is located at the wagon bridge, one-eighth of a mile below plant of the Pocatello Electric Power Company at Pocatello, Idaho. It was established May 18, 1897, by G. H. Nickerson. The rod is vertical and securely spiked to center pier of bridge. The bench mark is a spike driven into the end of a log in the east abutment of bridge and is opposite the 13-foot mark. The channel above the station is curved, while below it is straight. The right bank is high, but the left is liable to overflow at a 12-foot gage height. The bed of the stream is rocky. The current is sluggish at low stages. The observer is John A. Lillibridge, engineer at the power-house. The following discharge measurements were made by G. H. Nickerson and F. J. Mills in 1897:

May 20, gage height, 12.70 feet; discharge, 1,847 second-feet.
July 29, gage height, 6.95 feet; discharge, 123 second-feet.

Daily gage height, in feet, of Portneuf River at Pocatello, Idaho, for 1897.

Day.	May.	June.	July.	Aug.	Sept.	Day.	May.	June.	July.	Aug.	Sept.
1	.....	10.70	7.80	6.90	6.80	17	.....	8.20	7.40	6.80	7.00
2	.....	10.60	7.70	6.90	6.80	18	12.80	8.00	7.50	6.80	7.00
3	.....	10.50	7.80	6.90	6.80	19	12.70	8.00	7.30	7.10	7.00
4	.....	10.30	7.70	6.90	7.00	20	12.70	8.00	7.30	7.00	7.00
5	.....	10.10	7.70	6.90	7.10	21	12.70	8.00	7.20	7.00	6.90
6	.....	9.80	7.70	6.90	7.10	22	12.70	7.90	7.20	7.00	6.90
7	.....	9.70	7.90	6.90	7.10	23	12.70	8.00	7.00	6.90	6.90
8	.....	9.50	7.80	6.80	7.00	24	12.50	8.10	7.00	6.90	7.00
9	.....	9.30	7.70	7.00	6.90	25	12.40	8.00	7.00	6.60	7.00
10	.....	9.30	7.50	6.90	7.10	26	12.20	8.00	7.00	6.70	7.00
11	.....	9.10	7.50	6.90	7.00	27	11.90	8.00	6.90	6.80	7.00
12	.....	9.00	7.50	6.90	7.00	28	11.60	8.00	7.00	6.80	7.10
13	.....	8.90	7.40	6.90	7.00	29	11.40	8.00	6.90	6.80	7.10
14	.....	8.80	7.40	6.90	7.00	30	11.20	7.90	6.90	6.80	7.20
15	.....	8.60	7.40	6.90	7.00	31	10.90	.....	6.90	6.80	.....
16	.....	8.40	7.40	6.80	7.00						

MONTGOMERY STATION ON SNAKE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 334, is located at Montgomerys Ferry, 12 miles from Minidoka, Idaho, from which it is reached by stage. The gage is inclined and fastened to posts set in the ground. The bench mark is the head of a spike in the east post of the tool house, 1.2 feet above the ground and 52 feet west of the gage. Its elevation is 17.50 feet above datum. The letters "B. M." are marked in black paint on the post. The river is 800 feet wide at the section, with a hard gravel bottom. The observer is George Montgomery, the ferryman. The following are the discharge measurements as made from the ferryboat in 1897 by Cyrus C. Babb and G. H. Nickerson:

April 29, gage height, 4.63 feet; discharge, 9,473 second-feet.
June 8, gage height, 9.90 feet; discharge, 36,276 second-feet.

Daily gage height, in feet, of Snake River at Montgomerys Ferry, Idaho, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Day.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	5.15	12.15	6.00	3.25	2.60	17	3.20	9.75	8.90	4.70	2.80	2.70
2	.....	5.45	12.05	5.90	3.20	2.60	18	3.30	10.20	8.85	4.60	2.70	2.70
3	.....	5.70	12.00	5.80	3.20	2.60	19	3.45	10.45	8.75	4.50	2.70	2.70
4	.....	6.05	12.15	5.80	3.20	2.50	20	3.75	10.65	8.60	4.45	2.70	2.70
5	.....	6.45	12.10	5.90	3.20	2.60	21	3.95	10.85	8.15	4.35	2.70	2.70
6	.....	7.20	11.60	6.05	3.10	2.60	22	4.30	11.05	7.65	4.25	2.70	2.70
7	.....	7.75	10.80	6.15	3.00	2.70	23	4.55	11.45	7.25	4.15	2.70	2.70
8	.....	8.25	9.95	5.95	3.00	2.80	24	4.60	11.85	7.05	4.00	2.70	2.70
9	.....	8.80	9.40	5.65	3.00	2.70	25	4.45	12.10	6.85	3.85	2.70	2.70
10	.....	9.15	9.15	5.45	3.00	2.70	26	4.30	12.25	6.70	3.75	2.65	2.70
11	.....	9.15	9.35	5.30	2.90	2.70	27	4.20	12.45	6.55	3.70	2.60	2.70
12	.....	8.85	9.50	5.15	2.90	2.70	28	4.30	12.55	6.35	3.65	2.60	2.70
13	.....	8.75	9.35	5.05	2.90	2.70	29	4.60	12.60	6.15	3.60	2.60	2.70
14	.....	8.95	9.05	4.95	2.80	2.70	30	4.95	12.60	6.10	3.50	2.60	2.75
15	3.10	9.15	8.90	4.80	2.80	2.70	31	.....	12.35	.....	3.40	2.60	.....
16	3.20	9.35	8.90	4.70	2.80	2.70							

TOPONIS STATION ON MALAD AND LITTLE WOOD RIVERS.

This station, described in the Eighteenth Annual Report, Part IV, page 336, was established on June 2, 1896, on Malad and Little Wood rivers, at the wagon bridges near the railroad station of Toponis, Idaho. On the Malad River the rod of the wire gage is fastened to the stringer of the bridge, upper side. The 5-foot mark is opposite the center vertical. The distance from the end of the weight to the index marker is 13.60 feet. The outside edge of the pulley wheel is 1 foot from the zero of the rod. The bed of the river is of gravel, and not liable to change. During low stages the water is confined under the south span, but in floods it is under the two spans. The banks are not subject to overflow. The bridge over the Malad is one-half mile north of railroad station.

On the Little Wood River the station is one-half mile south of the railroad. The rod is fastened to the floor of the bridge, the 1.8-foot mark being opposite the iron vertical on the upper side of the bridge. The distance from the end of the weight to the index marker is 10.37 feet. The distance from the end of the rod to the outside edge of the pulley wheel is 1.97 feet. The channel is good and not obstructed by piers, but the banks overflow during flood stages. The observer is Will Hickman. The following discharge measurements were made by G. H. Nickerson and F. J. Mills in 1897:

Malad River:

May 21, gage height, 7.50 feet; discharge, 4,437 second-feet.
July 31, gage height, 2.80 feet; discharge, 81 second-feet.

Little Wood River:

May 21, gage height, 7.30 feet; discharge, 487 second-feet.

Daily gage height, in feet, of Malad River at Toponis, Idaho, for 1897.

Day.	June.	July.	Aug.	Sept.	Oct.	Day.	June.	July.	Aug.	Sept.	Oct.
1			2.80		2.40	17	4.00	3.30	2.60	2.00	
2			2.80		2.50	18	3.80	3.40	2.50	2.10	
3			2.80			19	3.50	3.30	2.50	2.30	
4		4.00	2.80			20		3.20	2.50	2.30	
5		4.20	2.80			21		3.20	2.50	2.30	
6	5.60	4.30	2.70			22		3.30	2.40	2.20	
7	5.60	4.10	2.70			23		3.20	2.30	2.30	
8	5.60	3.90	2.60			24		3.30	2.20	2.20	
9	5.50	3.70	2.60			25		3.20	2.00	2.40	
10	5.20	3.50	2.60			26		3.00	2.00	2.40	
11	5.00	3.50	2.60			27		3.00	2.00	2.40	
12	4.90	3.50	2.50			28		2.90	2.00	2.50	
13	4.50	3.50	2.50			29		2.90		2.50	
14	4.20	3.40	2.40			30		2.90		2.40	
15	4.40	3.30	2.60			31		2.80			
16	4.20	3.30	2.50								

Daily gage height, in feet, of Little Wood River at Toponis, Idaho, for 1897.

Day.	June.	July.	Aug.	Sept.	Oct.	Day.	June.	July.	Aug.	Sept.	Oct.
1		2.30	1.20	2.60	3.70	17	4.80	1.30	1.20	2.90	
2		2.20	1.10	2.30	3.80	18	3.60	1.10	1.20	3.00	
3		2.40	1.00	2.40		19	3.30	1.20	1.40	3.10	
4		2.20	1.00	2.40		20	3.20	1.30	1.40	3.00	
5		2.00	1.00	2.30		21	3.00	1.20	1.40	3.20	
6	6.50	1.90	1.00	2.20		22	3.40	1.20	1.40	3.30	
7	6.50	1.90	1.00	2.20		23	3.70	1.20	1.30	3.30	
8	5.50	1.70	1.00	2.30		24	3.90	1.10	1.40	3.30	
9	4.80	1.50	1.20	2.40		25	4.00	1.30	1.50	3.40	
10	4.60	1.30	1.20	2.50		26	4.10	1.20	2.00	3.40	
11	4.20	1.20	1.30	2.60		27	4.20	1.20	2.00	3.50	
12	4.00	1.20	1.20	2.60		28	4.40	1.20	2.20	3.40	
13	4.00	1.10	1.20	2.70		29	3.50	1.20	2.30	3.50	
14	3.80	1.10	1.10	2.80		30	2.50	1.20	2.90	3.60	
15	4.20	1.00	1.30	2.90		31		1.30	2.80		
16	4.00	1.00	1.30	2.90							

GRANDVIEW STATION ON BRUNEAU RIVER.

This station is described in the Eighteenth Annual Report, Part IV, page 339. The point of measurement is 10 miles east of Grandview, Idaho, below the head of the Bruneau ditch. Observations of gage height are regularly kept, and estimates of discharge are made from them by A. J. Wiley, chief engineer of the Owyhee Land and Irrigation Company. C. C. Gregg is the observer.

Daily gage height, in feet, of Bruneau River at Grandview, Idaho, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.60	1.65	1.70	2.30	4.80	4.45	2.40	1.40	1.15	1.30	1.60	1.75
2	1.60	1.65	1.70	2.25	4.75	4.20	2.40	1.40	1.15	1.30	1.65	1.70
3	1.55	1.65	1.70	2.30	4.90	4.00	2.40	1.50	1.15	1.30	1.70	1.70
4	1.55	1.65	1.70	2.25	5.00	3.65	2.35	1.50	1.15	1.35	1.65	1.65
5	1.55	1.70	1.70	2.65	5.10	3.60	2.35	1.40	1.15	1.35	1.60	1.65
6	1.55	1.95	1.70	3.50	5.30	3.50	2.30	1.35	1.15	1.35	1.60	1.65
7	1.60	2.70	1.75	3.75	5.50	3.40	2.20	1.35	1.15	1.40	1.70	1.75
8	1.55	2.20	1.75	3.45	5.60	3.50	2.15	1.30	1.15	1.40	1.65	1.80
9	1.55	2.05	1.70	3.10	5.25	3.45	2.15	1.30	1.20	1.40	1.65	1.80
10	1.55	1.95	1.65	3.60	4.70	3.60	2.10	1.30	1.20	1.50	1.60	1.75
11	1.50	1.80	1.65	4.40	4.50	3.45	2.10	1.30	1.20	1.55	1.65	1.80
12	1.50	1.80	1.65	5.00	4.45	3.35	2.00	1.30	1.20	1.55	1.70	1.80
13	1.50	1.80	1.60	4.50	4.35	3.30	1.95	1.30	1.20	1.60	1.70	1.80
14	1.60	1.70	1.50	4.60	4.40	3.30	2.00	1.30	1.20	1.55	1.70	1.85
15	1.60	1.60	1.55	4.60	4.55	3.30	2.00	1.35	1.25	1.60	1.70	1.85
16	1.60	1.80	1.60	4.65	4.60	3.25	2.00	1.25	1.25	1.60	1.70	1.80
17	1.60	1.70	1.65	4.80	4.65	3.15	1.95	1.25	1.25	1.65	1.70	1.70
18	1.60	1.65	1.65	5.10	4.80	3.10	1.90	1.25	1.25	1.65	1.70	1.75
19	1.50	1.65	1.65	5.50	5.00	3.00	1.90	1.25	1.30	1.60	1.70	1.70
20	1.50	1.65	1.65	6.00	5.15	2.90	1.90	1.25	1.30	1.60	1.75	1.80
21	1.60	1.65	1.65	5.75	5.35	2.80	1.85	1.05	1.30	1.60	1.75	1.70
22	1.70	1.65	1.60	5.15	5.65	2.65	1.80	1.10	1.30	1.60	1.75	1.75
23	1.70	1.70	1.60	4.50	5.50	2.60	1.65	1.10	1.30	1.60	1.85	1.70
24	1.65	1.65	1.60	4.00	5.65	2.60	1.60	1.10	1.30	1.65	1.85	1.70
25	1.65	1.65	1.65	3.70	5.45	2.60	1.60	1.10	1.30	1.65	1.80	1.70
26	1.60	1.65	7.00	3.80	5.10	2.50	1.65	1.10	1.30	1.65	1.80	1.75
27	1.60	1.65	7.00	4.00	4.70	2.50	1.55	1.15	1.30	1.65	1.75	1.70
28	1.50	1.65	4.00	4.60	5.10	2.50	1.50	1.10	1.30	1.65	1.70	1.80
29	1.55	.....	3.60	4.80	4.70	2.55	1.45	1.15	1.30	1.65	1.65	1.75
30	1.60	.....	2.80	5.00	4.50	2.20	1.45	1.15	1.30	1.65	1.70	1.70
31	1.70	.....	2.55	.....	4.50	.....	1.45	1.15	.....	1.65	.....	1.70

BOISE STATION ON BOISE RIVER.

This station, as described in the Eighteenth Annual Report, Part IV, page 340, is located about 9 miles above Boise, Idaho, at the mouth of the canyon. April 18 the river cut into the right bank of the station, carrying out the cable and leaving the gage on a small island, so that the record after that date is unreliable. A temporary gage was therefore established May 12 at the Broadway Bridge, at Boise, and a record kept by it until June 17, when a new gage was again placed in the canyon 1 mile above the old location. The inclined rod is firmly attached to a cottonwood tree. The bench mark is a 20-penny spike in the upstream face of the 6 by 8 cable support, about 2 feet above the ground. Its elevation is 15.00 feet above datum; also two spikes in same post are 14.00 feet above datum. Discharge measurements are made from a cable and car, 50 feet below the gage. An auxiliary cable for flood measurements is placed 117 feet above the main cable. The observer is Mrs. Ed. Marnell. The following are the discharge measurements made on the Boise River by F. J. Mills and others in 1897:

April 21, at Star bridge, discharge, 24,312 second-feet.
May 18, at Broadway bridge, gage height, 4.30 feet; discharge, 23,522 second-feet.
June 29, gage height, 3.25 feet; discharge, 3,526 second-feet.
August 6, gage height, 1.60 feet; discharge, 1,357 second-feet.
September 18, gage height, 1.30 feet; discharge, 987 second-feet.
October 25, gage height, 1.50 feet; discharge, 1,256 second-feet.

Daily gage height, in feet, of Boise River at Boise, Idaho, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	2.00	1.90	1.70	3.60	7.30	.....	3.20	1.60	1.20	1.20	1.35
2	1.90	1.80	1.70	3.30	8.00	.....	3.60	1.60	1.30	1.25	.....
3	1.90	1.60	1.90	3.20	8.20	.....	3.30	1.50	1.30	1.25	.....
4	1.80	1.60	2.00	3.30	8.00	.....	3.05	1.55	1.30	1.25	1.30
5	1.80	1.90	2.00	3.20	8.00	.....	3.05	1.55	1.40	1.25	.....
6	1.70	2.00	1.90	3.50	7.50	.....	2.90	1.55	1.40	1.25	.....
7	1.70	1.90	2.00	3.50	7.00	.....	2.75	1.55	1.40	1.30	.....
8	1.80	2.40	2.10	3.40	7.00	.....	2.70	1.50	1.30	1.25	1.30
9	1.80	2.40	2.00	3.90	.....	.....	2.40	1.50	1.30	1.25	.....
10	1.90	2.20	1.90	4.30	.....	.....	2.30	1.45	1.40	1.30	.....
11	1.70	2.10	1.90	5.00	.....	.....	2.35	1.45	1.40	1.35	1.35
12	1.60	2.10	1.70	5.60	.....	.....	2.35	1.45	1.40	1.40	.....
13	1.40	2.00	1.50	6.00	.....	.....	2.30	1.40	1.50	1.40	.....
14	1.20	2.00	1.70	6.20	.....	.....	2.30	1.40	1.50	1.35	.....
15	1.20	2.00	1.70	7.30	.....	.....	2.30	1.40	1.40	1.35	1.30
16	1.20	1.90	1.70	8.00	.....	.....	2.20	1.35	1.40	1.35	.....
17	1.10	1.90	2.00	8.90	.....	4.00	2.20	1.30	1.40	1.30	.....
18	1.10	1.80	2.00	9.00	.....	3.80	2.30	1.30	1.30	1.30	1.50
19	1.10	1.80	1.90	9.30	.....	3.50	2.20	1.25	1.30	1.35	.....
20	1.40	1.70	1.80	8.90	.....	3.50	2.00	1.25	1.30	1.25	.....
21	1.60	1.60	1.80	6.80	.....	3.40	1.95	1.20	1.40	1.30	.....
22	1.60	1.70	1.90	6.70	.....	3.50	1.80	1.15	1.40	1.30	1.40
23	1.80	1.70	2.20	6.60	.....	3.80	2.00	1.20	1.40	1.30	.....
24	1.50	1.70	2.60	6.70	.....	3.40	1.95	1.20	1.40	1.40	.....
25	1.40	1.60	3.00	6.90	.....	3.30	1.90	1.20	1.40	1.50	1.50
26	1.40	1.50	4.00	7.40	.....	3.30	1.80	1.30	1.20	1.50	.....
27	1.20	1.50	4.20	7.40	.....	3.40	1.80	1.30	1.20	1.40	.....
28	1.20	1.60	4.00	7.50	.....	3.30	1.75	1.30	1.20	1.35	.....
29	1.60	.....	3.90	7.00	.....	3.20	1.70	1.30	1.20	1.35	1.30
30	1.80	.....	3.70	6.50	.....	3.20	1.60	1.30	1.20	1.35	.....
31	1.90	.....	3.50	.....	.....	.....	1.65	1.20	.....	.....	.....

VALE STATION ON MALHEUR RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 345, is located at the iron highway bridge at Vale, Oregon. The observer is E. R. Murray, postmaster. The station is distant from the observer's house about one-fourth of a mile. The gage is inclined, and is in two parts. The lower part is graduated from 1.6 to 9.1 feet, the distance between the footmarks being 1.95 feet. The upper part is graduated from 9.1 to 11.7 feet, the distance between the footmarks being 3 feet. The channel is composed of earth and sand and is shifting. The bench mark is on a flat rock, nearly buried, above the right bank of the river, 50 feet southeast of south abutment of new bridge, and is 12.32 feet above the zero of the gage. Measurements are made from the iron highway bridge. The following discharge measurements were made in 1897 by Frank Shirley and G. H. Nickerson:

April 17, gage height, 7.15 feet; discharge, 4,857 second-feet.
May 15, gage height, 4.75 feet; discharge, 1,883 second-feet.
May 28, gage height, 4.37 feet; discharge, 1,694 second-feet.

Daily gage height, in feet, of Malheur River at Vale, Oregon, for 1897.

Day.	Apr.	May.	June.	July.	Day.	Apr.	May.	June.	July.	Day.	Apr.	May.	June.	July.
1..	.....	6.10	3.75	2.48	12...	.....	5.05	2.65	2.10	23...	7.70	4.50	2.40	1.45
2..	.....	6.10	3.55	2.40	13...	.....	4.95	2.55	2.00	24...	7.20	4.45	2.40	1.40
3..	.....	6.10	3.45	2.40	14...	.....	4.80	2.50	1.98	25...	6.60	4.40	2.38	1.40
4..	.....	5.95	3.25	2.35	15...	6.55	4.70	2.50	1.90	26...	6.45	4.35	2.85	1.40
5..	.....	5.95	3.10	2.30	16...	6.75	4.70	2.50	1.90	27...	6.65	4.35	2.68	1.38
6..	.....	5.90	3.20	2.30	17...	7.25	4.80	2.45	1.87	28...	7.00	4.35	2.65	1.33
7..	.....	6.05	3.05	2.28	18...	8.30	5.00	2.40	1.75	29...	7.10	4.15	2.60	1.30
8..	.....	6.10	3.00	2.20	19...	8.95	4.90	2.40	1.65	30...	6.60	3.95	2.55	1.25
9..	.....	5.80	2.90	2.20	20...	9.30	4.90	2.50	1.55	31...	.....	3.80	.....	1.20
10..	.....	5.40	2.95	2.18	21...	10.10	4.85	2.43	1.50					
11..	.....	5.15	2.75	2.13	22...	8.50	4.60	2.40	1.50					

PAYETTE STATION ON PAYETTE RIVER.

This station, as described in the Eighteenth Annual Report, Part IV, page 350, is located at the highway bridge at Payette, Idaho. The observer is J. A. Ballinger, the town marshal at Payette. The station is distant from the observer's house about one-half mile. The gage is vertical, of pine plank, spiked to a wooden pier, graduated from 0 to 12.5 feet. It is easily read from the bridge. The character of the channel is sandy and shifting. The point 12.5 on the gage is level with the top of the pier, on which is the mark "B. M." Measurements of discharge were made as follows by G. H. Nickerson in 1897:

May 14, gage height, 7.40 feet; discharge, 19,422 second-feet.
May 27, gage height, 8.20 feet; discharge, 26,707 second-feet.

Daily gage height, in feet, of Payette River at Payette, Idaho, for 1897.

Day.	May.	June.	July.	Day.	May.	June.	July.	Day.	May.	June.	July.
1	.....	7.50	3.80	12	.....	5.30	2.80	22	8.50	4.10	1.90
2	.....	7.00	3.90	13	.....	5.30	2.70	24	8.40	4.00	1.90
3	.....	6.80	3.90	14	7.40	5.30	2.60	25	8.50	4.00	1.80
4	.....	6.10	3.90	15	7.60	5.20	2.50	26	8.60	3.90	1.80
5	.....	5.90	3.70	16	7.80	5.00	2.40	27	8.20	3.80	1.70
6	.....	6.10	3.60	17	8.00	4.90	2.30	28	7.90	3.80	1.70
7	.....	5.90	3.50	18	8.30	4.70	2.20	29	7.80	3.80	1.60
8	.....	5.60	3.30	19	8.40	4.60	2.20	30	7.80	3.90	1.60
9	.....	5.60	3.20	20	8.60	4.40	2.10	31	7.60	.....	1.50
10	.....	5.50	3.00	21	8.70	4.30	2.10				
11	.....	5.40	2.90	22	8.50	4.20	2.00				

WEISER STATION ON WEISER RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 352, is about 10 miles above the town of Weiser, Idaho, at the mouth of the canyon. The gage is firmly fastened to posts driven into the ground. The 6-foot mark is 13.46 feet below a bench mark on a large bowlder 30 feet south of the gage. The observer is J. W. Lane, whose house is about one-fourth of a mile from the gage. The channel is straight for some distance above and below the section, the banks are high, and the bed is gravelly. The following discharge measurements were made in 1897 by F. J. Mills, Cyrus C. Babb, and others:

May 26, gage height, 4.95 feet; discharge, 5,026 second-feet.
August 5, gage height, 0.70 foot; discharge, 100 second-feet.
October 23, gage height, 0.95 foot; discharge, 153 second-feet.

Daily gage height, in feet, of Weiser River at Weiser, Idaho, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Day.	Apr.	May.	June.	July.	Aug.	Sept.
1....	5.10	5.60	3.70	1.80	0.80	0.70	17.....	7.10	6.00	2.30	1.30	0.60	0.80
2....	5.85	5.80	3.40	1.80	.80	.70	18.....	7.50	6.00	2.30	1.20	.60	.80
3....	6.00	5.90	3.20	2.00	.80	.70	19.....	7.90	5.90	2.20	1.20	.60	.80
4....	6.10	6.00	3.10	1.90	.70	.70	20.....	8.30	5.90	2.10	1.20	.60	.80
5....	7.00	6.20	3.00	1.80	.70	.70	21.....	7.90	5.90	2.10	1.20	.60	.80
6....	6.90	6.40	3.00	1.70	.70	.70	22	7.60	5.80	2.00	1.10	.60	.80
7....	6.70	6.90	2.90	1.70	.70	.70	23.....	7.30	5.50	2.00	1.10	.60	.80
8....	6.50	6.40	2.90	1.70	.60	.80	24.....	5.70	5.00	2.00	1.10	.60	.90
9....	6.90	5.80	2.80	1.60	.60	.80	25.....	5.60	5.20	1.90	1.00	.60	.90
10....	7.00	5.40	2.70	1.60	.60	.80	26.....	6.00	5.00	1.90	1.00	.60	.90
11....	7.00	5.40	2.60	1.50	.60	.80	27.....	6.50	4.30	2.10	1.00	.60	.90
12....	6.50	5.40	2.60	1.50	.60	.80	28.....	6.90	4.20	2.00	1.00	.60	.90
13....	6.60	5.50	2.50	1.40	.60	.80	29.....	6.50	4.10	1.90	.90	.60	.90
14....	6.60	5.70	2.50	1.40	.60	.80	30.....	5.80	4.00	1.80	.90	.60	.90
15....	6.50	5.90	2.40	1.30	.60	.80	31.....	.....	4.00	.....	.90	.60	.....
16....	6.70	6.00	2.40	1.30	.60	.80							

HOOPER STATION ON PALOUSE RIVER.

This station is located on the Palouse River at Hooper, Washington. It was established April 1, 1897, by the land department of the Northern Pacific Railroad. September 9, 1897, this Survey took charge of the station, placing the gage rod 1 mile below the former location and opposite the water tank, and stretching a cable across the river for discharge measurements. The rod is inclined, fastened to posts driven into the right bank. The bench mark is a point of rock, marked with red paint, on a ledge on the left bank of the river opposite the gage, and its elevation is 7.60 feet above datum. When the new gage reads 2.1 feet the height on the Northern Pacific Railroad gage is 6.1 feet. The channel is gravelly and not liable to change. The left bank is high and can not overflow. The right bank overflows in extreme high water. The initial point for sounding is the cable post on left bank. The station is about 3 miles above the mouth of Cow Creek and 2 miles below the head of the ditch of the Palouse Irrigation Company, carrying 25 second-feet when full The observer is Frank Hill, rancher. Discharge measurements were made by Cyrus C. Babb in 1897, as follows:

September 9, gage height, 2.10 feet; discharge 73 second-feet.
October 1, gage height, 1.90 feet; discharge, 50 second-feet.

Daily gage height, in feet, of Palouse River at Hooper, Washington, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	10.10	8.45	6.08	6.42	5.55	.....	1.90	2.00	3.20
2	9.85	8.20	6.08	5.42	5.52	.....	1.90	2.00	3.30
3	10.18	8.10	6.03	6.42	5.62	.....	1.95	2.05	3.60
4	10.11	8.12	6.01	6.42	5.68	.....	2.00	2.05	3.70
5	9.98	8.00	5.95	6.50	5.65	.....	2.00	2.05	3.60
6	9.98	7.98	5.94	6.50	5.65	.....	1.95	2.05	3.60
7	9.97	7.98	5.93	6.45	5.72	.....	1.95	2.20	5.00
8	10.22	8.12	6.02	6.36	5.82	.....	1.90	2.20	5.95
9	10.08	8.00	6.21	6.31	5.85	2.10	1.90	2.10	7.00
10	9.90	7.90	6.20	6.25	5.85	2.20	1.95	2.20	7.05
11	9.80	7.66	6.15	6.20	5.92	2.10	2.00	2.25	6.90
12	10.15	7.44	6.07	6.15	5.88	2.10	2.00	2.30	6.30
13	10.58	7.40	6.07	6.46	5.80	2.20	1.95	2.50	6.60
14	10.15	7.20	6.07	6.39	5.80	2.20	1.90	2.70	6.50
15	9.80	7.05	6.10	6.31	5.80	2.10	1.90	3.50	7.55
16	9.97	7.05	6.10	6.22	5.80	2.10	1.90	3.90	7.00
17	10.04	7.05	6.18	6.18	5.78	2.00	1.95	3.60	6.30
18	10.17	7.11	6.28	6.12	5.77	2.00	1.95	3.40	5.40
19	10.25	7.00	6.55	6.05	5.95	2.00	1.95	3.40	5.20
20	10.30	6.89	7.20	6.02	5.97	2.00	2.00	3.60	4.90
21	10.24	6.78	7.50	5.99	5.95	2.00	2.00	4.35	4.70
22	10.10	6.63	7.20	5.99	5.89	2.00	2.00	4.80	4.60
23	9.80	6.55	7.00	5.94	5.87	2.00	2.00	4.70	4.50
24	9.40	6.49	6.88	5.93	5.89	1.90	2.00	4.20	4.40
25	9.08	6.40	6.85	5.93	5.82	1.90	2.00	4.00	4.35
26	8.80	6.39	6.77	5.92	5.86	1.90	2.05	3.65	4.60
27	8.69	6.38	6.62	5.91	5.90	1.90	2.05	3.60	4.65
28	8.72	6.38	6.58	5.80	5.91	1.90	2.00	3.50	4.90
29	8.89	6.37	6.62	5.70	5.85	1.90	2.00	3.40	6.70
30	8.74	6.22	6.50	5.65	5.82	1.90	2.00	3.30	7.10
31	.....	6.13	.....	5.60	5.80	.....	2.00	.....	7.40

Readings on Northern Pacific Railroad gage April 1 to August 31. United States Geological Survey gage established September 9 and located 1 mile below Northern Pacific Railroad gage, and also made to read 4 feet lower.

SELAH STATION ON YAKIMA RIVER.

This station is located on the Yakima River at the Northern Pacific Railway bridge, or first crossing of the Yakima, 7 miles above the town of North Yakima, Washington. It was established by Cyrus C. Babb, May 19, 1897, after the Naches station had been discontinued, with the idea that the difference in discharge between this station and the one at Union Gap would give approximately the discharge of the Natches River. The gage is the wire type, the rod being fastened to the guard rail of the bridge, west span, lower side. The length of gage wire is 39 feet. The pulley distance is 2 feet. The bench mark is the top of the north sill of the clearance posts, about 150 feet west of the bridge, and its elevation is 35.21 feet above gage datum. During the months of September and October the bridge was undergoing repairs, and gage records could not be kept. The observer is Pat Gallagher, section foreman. The following measurements were made in 1897 by Cyrus C. Babb:

May 19, gage height, 10.77 feet; discharge, 13,904 second-feet.
May 26, gage height, 8.88 feet; discharge, 7,424 second-feet.
June 10, gage height, 7.60 feet; discharge, 4,859 second-feet.
June 18, gage height, 6.90 feet; discharge, 3,185 second-feet.
July 3, gage height, 7.10 feet; discharge, 3,636 second-feet.
July 10, gage height, 6.28 feet; discharge, 2,300 second-feet.
July 17, gage height, 5.81 feet; discharge, 1,751 second-feet.
July 29, gage height, 5.15 feet; discharge, 1,019 second-feet.
August 13, gage height, 4.91 feet; discharge, 810 second-feet.

Daily gage height, in feet, of Yakima River at Selah, Washington, for 1897.

Day.	May.	June.	July.	Aug.	Oct.	Nov.	Dec.
1	.....	8.40	6.90	.....	.....	4.90	6.20
2	.....	8.20	6.90	5.00	.....	4.90	6.20
3	.....	8.10	7.20	5.00	.....	4.90	6.20
4	.....	7.80	.....	5.00	.....	4.90	6.20
5	.....	7.60	7.10	4.90	.....	4.90	.....
6	.....	.....	6.90	4.90	.....	4.90	6.20
7	.....	7.50	6.80	4.90	.....	.....	6.20
8	.....	7.70	6.60	.....	.....	4.90	6.60
9	.....	7.80	6.50	4.90	.....	4.90	6.80
10	.....	7.50	6.30	4.90	.....	4.90	6.80
11	.....	7.30	.....	4.90	.....	5.70	6.80
12	.....	7.20	6.10	4.90	.....	6.50	.....
13	.....	.....	6.10	4.80	.....	7.60	6.80
14	.....	7.20	6.10	4.80	.....	.....	6.40
15	.....	7.20	6.00	.....	.....	7.30	6.40
16	.....	7.00	5.90	4.80	.....	7.00	6.30
17	.....	7.00	5.90	4.80	.....	6.60	6.10
18	.....	7.00	.....	4.80	.....	7.00	6.10
19	10.80	6.90	5.80	4.70	.....	12.30	.....
20	10.60	6.80	5.70	4.70	4.90	11.60	6.00
21	10.40	6.70	5.60	4.70	4.90	.....	5.90
22	10.30	6.90	5.60	.....	4.90	9.10	5.90
23	.....	7.30	5.60	.....	4.90	8.40	5.70
24	9.70	7.30	5.60	.....	.....	7.90	5.60
25	9.20	7.20	.....	.....	4.90	7.40	5.60
26	8.90	7.20	5.40	.....	4.90	6.90	.....
27	8.70	.....	5.30	.....	4.90	6.30	5.60
28	8.50	7.10	5.30	.....	4.90	.....	6.00
29	8.30	7.00	5.20	.....	4.90	6.20	8.60
30	.....	6.90	5.10	.....	4.90	6.20	9.20
31	8.30	.....	5.10	.....	.....	.....	8.80

NORTH YAKIMA STATION ON NACHES RIVER.

This station, as described in the Eighteenth Annual Report, Part IV, page 355, is located at the highway bridge, 2 miles from North Yakima, Washington, at the mouth of the river. The rod, a 2 by 6 inch timber, is fastened to the crib bulwark, just below the highway bridge. The flood of November, 1896, modified the channel very greatly, depositing a large mass of coarse gravel and small bowlders along the right side of the channel at the section, so that the rod was 50 feet, more or less, from the edge of the water at low stages. The current is swift, even at low water. On account of the instability of the channel the station was abandoned in February, 1897, although a number of discharge measurements were made during the season. The station was located below the heads of a number of ditches. May 19, 1897, a station was established on the Yakima River, 5 miles above the mouth of the Naches, at the Northern Pacific Railway bridge near Selah, Washington, with the idea that the difference in discharge between this station and the one at Union Gap would give approximately the discharge of the Naches River. Two ditches, those of the Moxee Valley, are taken out between the two points, but their amount is about counterbalanced by that received from Ahtanum Creek and the wastage at Old Town. The following discharge measurements were made in 1897 by Cyrus C. Babb and Sydney Arnold:

June 10, discharge, 3,178 second-feet.
June 18, discharge, 1,993 second-feet.
July 29, discharge, 781 second-feet.
September 22, discharge, 385 second-feet.
November 15, discharge, 1,500 second-feet.

Daily gage height, in feet, of Naches River at North Yakima, Washington, for 1897.

Day.	Jan.	Feb.	Day.	Jan.	Feb.	Day.	Jan.	Feb.	Day.	Jan.	Feb.
1	3.00	3.00	9	3.00	2.80	17	2.70	2.50	25	3.50	.....
2	3.00	3.00	10	2.90	2.70	18	2.70	2.50	26	3.40	.....
3	2.90	3.00	11	2.90	2.70	19	2.80	2.40	27	3.30	.....
4	2.90	2.90	12	2.90	2.70	20	3.10	2.40	28	3.20	.....
5	3.00	2.90	13	2.80	2.60	21	3.30	.....	29	3.10	.....
6	3.00	2.90	14	2.80	2.60	22	3.60	.....	30	3.10	.....
7	3.00	2.90	15	2.70	2.60	23	3.60	.....	31	3.10	.....
8	3.00	2.80	16	2.70	2.50	24	3.50	.....			

UNION GAP STATION ON YAKIMA RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 356, is located at Union Gap, 6 miles below North Yakima, Washington, and 1,000 feet below the highway bridge. The gage rod is inclined and is attached to a willow stump and to posts set into the ground and loaded with rock. The bench mark is a stone, marked "B. M.," 39 feet west of the gage and 8.5 feet east of the railroad track. It is 29.85 feet above gage datum. The gaging cable and car is about 50 yards above the rod. The channel of the river is straight for several hundred feet, both above and below the cable. During floods a portion of the water passes through a depression in the left bank, and this must be measured from the bridge. The right bank is high and will not overflow. The observer is Ed. Farmer, section foreman. The following measurements were made in 1897 by Cyrus C. Babb:

May 15, gage height, 10.90 feet; discharge, 19,234 second-feet.
May 25, gage height, 9.40 feet; discharge, 15,543 second-feet.
June 9, gage height, 8.15 feet; discharge, 8,938 second-feet.
June 16, gage height, 7.25 feet; discharge, 5,901 second-feet.
July 2, gage height, 7.35 feet; discharge, 6,275 second-feet.
July 9, gage height, 6.45 feet; discharge, 3,973 second-feet.
July 15, gage height, 6.05 feet; discharge, 3,097 second-feet.
July 23, gage height, 5.48 feet; discharge, 2,361 second-feet.
August 7, gage height, 4.80 feet; discharge, 1,314 second-feet.
September 6, gage height, 4.55 feet; discharge, 1,140 second-feet.
September 21, gage height, 4.26 feet; discharge, 683 second-feet.

Daily gage height, in feet, of Yakima River at Union Gap, Washington, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.60	.....	.....	6.80	9.00	8.70	7.20	4.90	4.40	4.30	4.40	6.30
2	.....	.....	.....	6.90	9.20	8.60	7.40	4.80	4.30	4.30	4.40	6.30
3	.....	.....	.....	6.80	9.40	8.50	7.35	4.80	4.30	4.30	4.40	6.20
4	.....	.....	.....	7.40	9.60	8.30	7.20	4.80	4.40	4.30	4.40	6.10
5	.....	.....	5.60	7.60	9.80	8.20	7.10	4.80	4.40	4.20	4.40	6.00
6	.....	.....	.....	7.90	9.60	8.10	6.90	4.80	4.40	4.20	4.40	6.80
7	.....	.....	.....	7.90	9.00	8.00	6.70	4.80	4.40	4.30	4.40	6.90
8	.....	.....	.....	7.90	9.00	8.30	6.60	4.80	4.40	4.20	4.40	7.10
9	.....	.....	.....	8.70	9.10	8.20	6.50	4.80	4.40	4.20	4.50	7.00
10	.....	.....	5.40	9.40	9.20	7.90	6.30	4.70	4.40	4.20	4.80	6.90
11	.....	.....	.....	8.40	9.20	7.80	6.30	4.70	4.40	3.20	5.60	6.80
12	.....	.....	.....	9.60	9.10	7.60	6.20	4.70	4.40	4.20	6.50	6.70
13	.....	.....	.....	9.60	9.40	7.70	6.10	4.70	4.30	4.20	7.20	6.70
14	.....	.....	5.20	10.00	9.90	7.50	6.00	4.70	4.30	4.20	7.00	6.60
15	5.40	5.50	5.10	10.60	10.00	7.40	6.00	.....	4.30	4.20	6.80	6.50
16	.....	.....	5.10	10.90	11.40	7.30	6.00	.....	4.30	4.20	5.90	6.40
17	.....	.....	5.10	11.40	11.40	7.20	5.90	.....	4.20	4.20	5.80	6.30
18	.....	.....	5.30	.....	11.40	7.20	5.80	.....	4.20	4.20	6.10	6.10
19	.....	.....	5.30	11.00	11.20	7.00	5.80	.....	4.30	4.20	11.00	6.10
20	.....	6.70	5.20	12.00	10.90	6.90	5.70	4.60	4.30	4.20	11.60	5.90
21	.....	.....	5.10	11.60	10.80	6.80	5.60	4.60	4.30	4.30	9.60	5.80
22	.....	.....	5.10	11.00	10.40	7.10	5.50	4.60	4.30	4.40	9.00	5.60
23	.....	.....	5.20	10.60	10.20	7.40	5.50	4.50	4.20	4.40	8.30	5.70
24	.....	.....	6.00	9.00	10.00	7.40	5.40	4.50	4.20	4.50	7.70	5.70
25	.....	.....	6.80	9.40	9.80	7.30	5.40	4.50	4.20	4.50	7.30	5.60
26	.....	6.00	6.40	9.60	9.60	7.20	5.30	4.50	4.30	4.50	6.90	5.60
27	.....	.....	6.20	9.80	9.40	7.10	5.30	4.50	4.20	4.40	6.70	5.70
28	.....	.....	6.40	9.70	9.20	7.30	5.20	4.40	4.20	4.40	6.60	5.70
29	.....	.....	6.80	9.40	9.10	7.20	5.10	4.40	4.20	4.50	6.60	5.70
30	.....	.....	6.60	9.10	9.00	7.10	5.10	4.40	4.30	4.50	6.30	8.80
31	.....	.....	6.60	.....	8.90	.....	5.10	4.40	.....	4.40	.....	8.20

KIONA STATION ON YAKIMA RIVER.

This station, as described in the Eighteenth Annual Report, Part IV, page 358, is located at the highway bridge at Kiona, Washington. The rod of the wire gage is placed on the lower side of the bridge. The distance from the end of the weight to the index marker is 27.21 feet. From the end of the rod to the outside edge of the pulley wheel it is 2 feet. The section is an excellent one for measurements. The channel is straight for some distance above and below. The banks are medium high and the bed is composed of a firm gravel. The observer is W. A. Kelso. The following discharge measurements were made in 1897 by Cyrus C. Babb and Sydney Arnold:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
May 8	11.50	16,557	June 15	8.05	6,908	Aug. 5	4.61	1,217
May 24	11.52	16,344	July 7	7.15	5,118	Aug. 30	4.10	762
May 29	9.74	11,338	July 13	6.30	3,475	Nov. 6	4.08	839
June 8	8.75	8,868	July 21	5.55	2,318	Dec. 29	8.54	7,459

Daily gage height, in feet, of Yakima River at Kiona, Washington, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.00	7.15	6.08	6.81	10.48	10.67	7.52	4.80	4.00	3.90	.....	6.53
2	6.87	.....	6.27	6.68	10.40	10.16	7.42	.....	4.05	.....	4.12	6.50
3	.....	6.94	6.31	6.69	10.36	9.60	7.80	4.70	4.10	3.90	4.10	.....
4	.....	.....	6.30	7.05	10.22	9.30	7.80	4.68	4.12	3.90	4.09	6.24
5	6.55	6.82	.....	7.16	10.34	8.84	7.64	4.61	4.16	3.87	4.08	6.15
6	6.45	6.88	.....	7.22	10.48	8.67	7.42	4.55	4.18	3.86	4.08	6.71
7	6.52	.....	.....	7.42	11.22	8.61	7.15	4.50	4.18	3.85	4.12	7.50
8	6.50	.....	.....	7.75	11.50	8.80	6.98	4.50	4.16	3.84	4.15	8.22
9	.....	.....	.....	7.69	11.34	8.90	6.85	4.48	4.10	3.80	4.18	8.21
10	6.54	6.41	.....	7.98	10.79	8.75	6.64	4.41	4.06	3.78	4.19	7.95
11	.....	6.38	5.85	9.14	10.42	8.42	6.35	4.40	4.00	3.78	4.21	7.82
12	.....	6.85	5.78	10.01	10.26	8.08	6.32	4.40	4.00	.....	4.44	7.77
13	6.44	6.84	5.56	10.04	10.54	8.15	6.30	4.38	3.98	3.76	5.85	7.70
14	.....	.....	5.66	10.17	11.14	8.12	6.25	4.38	3.97	3.76	7.51	7.50
15	.....	.....	5.71	10.62	11.92	8.05	6.07	4.35	3.95	3.76	7.42	7.55
16	6.13	6.95	5.68	11.18	12.56	7.78	6.00	4.28	3.90	3.77	6.60	7.50
17	.....	.....	5.70	11.74	12.85	7.58	5.85	4.27	3.94	3.80	6.48	7.30
18	6.04	.....	5.75	12.40	13.08	7.50	5.80	4.27	3.94	3.82	6.34	6.95
19	6.07	.....	5.80	13.17	13.30	7.41	5.76	4.23	3.91	3.85	8.97	6.68
20	6.00	6.50	5.80	13.92	13.14	7.25	5.58	4.20	3.89	3.88	11.67	6.40
21	.....	.....	5.72	14.42	12.81	7.10	5.54	4.20	3.90	3.90	12.50	6.30
22	6.78	.....	5.69	13.49	.....	7.11	5.50	4.22	3.90	3.98	11.66	6.15
23	8.82	.....	5.62	12.85	12.30	7.45	5.45	4.15	3.90	.....	10.82	6.10
24	.....	.....	.....	11.98	11.50	7.80	5.33	4.15	3.91	4.10	9.42	6.00
25	.....	.....	5.84	11.24	10.86	7.86	5.27	.....	3.94	4.16	8.38	5.95
26	8.15	.....	7.02	11.10	10.70	7.77	5.27	4.14	3.90	4.18	8.00	5.92
27	.....	6.00	7.76	11.32	10.50	7.62	5.16	4.14	3.83	4.17	7.58	5.90
28	.....	.....	7.42	11.50	10.00	7.60	5.07	4.10	3.83	4.17	7.03	6.00
29	7.55	.....	7.44	11.35	9.75	7.72	4.97	4.08	3.84	.....	6.95	7.90
30	7.50	.....	7.26	10.72	9.86	7.55	4.90	4.04	3.86	.....	6.63	10.39
31	7.35	.....	6.95	.....	10.60	.....	4.80	4.00	.....	.....	.....	10.55

SPOKANE STATION ON SPOKANE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 359, is located at the bridge of Oregon Railway and Navigation Company at Spokane, Washington. The rod of the wire gage is fastened to the upper guard rail in the west span of the bridge. The distance from the end of the weight to the index is 22.0 feet, and from the zero of the rod to the outside edge of the pulley 1.80 feet. The gage was connected with a bench mark of the city engineering department and referred to sea level, the rod datum being 1,880 feet above sea level. The channel is straight for some distance above and below the section. The bed is gravelly and is practically unchangeable. The banks are high and are only overflowed during extraordinary floods. The velocity is quite swift, even during low water. The observer is Z. Taylor, telegraph operator, residing within 400 feet of the bridge. The following discharge measurements were made in 1897 by Cyrus C. Babb and others:

May 20, gage height, 10.80 feet; discharge, 29,084 second-feet.
June 29, gage height, 5.16 feet; discharge, 9,026 second-feet.
July 21, gage height, 4.05 feet; discharge, 7,893 second-feet.
September 11, gage height, 1.92 feet; discharge, 2,575 second-feet.
October 20, gage height, 1.50 feet; discharge, 2,011 second-feet.

Daily gage height, in feet, of Spokane River at Spokane, Washington, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.50	4.00	3.20	4.75	11.10	8.60	5.00	3.20	1.90	1.70	1.45	5.00
2	5.40	4.00	3.15	4.80	10.90	8.40	4.95	3.10	1.90	1.70	1.45	4.90
3	5.30	4.00	3.15	4.90	10.50	8.20	4.95	3.05	1.90	1.65	1.45	4.80
4	5.20	4.00	3.15	4.90	10.50	7.85	4.95	3.00	1.85	1.65	1.45	4.60
5	5.20	3.90	3.15	5.05	10.40	7.60	5.00	3.00	1.85	1.60	1.45	4.50
6	5.00	3.80	3.15	5.20	10.40	7.10	5.00	2.95	1.85	1.60	1.45	4.60
7	5.00	3.75	3.15	5.30	10.60	6.70	5.00	2.85	1.85	1.60	1.45	4.70
8	4.80	3.75	3.15	5.45	10.90	6.50	5.00	2.75	1.90	1.60	1.45	5.00
9	4.80	3.70	3.15	5.50	11.20	6.30	5.00	2.70	1.95	1.55	1.50	5.40
10	4.70	3.70	3.10	5.70	11.20	6.20	5.00	2.65	1.95	1.55	1.50	5.70
11	4.60	3.65	3.10	6.10	10.90	6.15	4.90	2.65	1.90	1.50	1.50	5.90
12	4.50	3.60	3.10	6.70	10.60	6.05	4.90	2.60	1.90	1.50	1.60	6.00
13	4.35	3.60	3.00	7.00	10.40	5.90	4.80	2.50	1.90	1.50	1.80	6.00
14	4.30	3.60	2.95	7.30	10.30	5.70	4.70	2.50	1.90	1.50	2.45	6.00
15	4.25	3.60	2.90	7.60	10.20	5.50	4.60	2.45	1.90	1.50	2.80	6.00
16	4.20	3.55	2.90	8.00	10.20	5.40	4.50	2.40	1.85	1.50	3.00	6.00
17	4.20	3.55	2.90	8.50	10.50	5.35	4.40	2.35	1.80	1.50	3.05	5.90
18	4.00	3.55	2.90	8.90	10.70	5.30	4.30	2.30	1.80	1.50	3.20	5.80
19	4.00	3.50	2.90	9.40	10.80	5.40	4.20	2.25	1.80	1.50	3.40	5.70
20	3.90	3.50	2.90	10.20	10.95	5.40	4.15	2.25	1.75	1.50	3.90	5.50
21	3.80	3.50	2.85	11.00	10.95	5.40	4.05	2.20	1.75	1.50	4.90	5.35
22	3.90	3.50	2.85	11.60	10.85	5.45	4.00	2.20	1.75	1.50	5.40	5.20
23	3.80	3.50	2.90	11.80	10.70	5.45	3.90	2.15	1.75	1.50	5.60	5.00
24	3.85	3.45	2.90	11.80	10.50	5.40	3.80	2.10	1.75	1.45	5.70	4.90
25	4.00	3.30	2.90	11.60	10.30	5.40	3.70	2.05	1.70	1.45	5.70	4.80
26	4.05	3.25	3.15	11.40	10.10	5.40	3.60	2.05	1.70	1.45	5.65	4.70
27	4.00	3.25	3.60	11.15	9.80	5.30	3.50	2.00	1.70	1.45	5.60	4.55
28	3.90	3.20	4.10	11.30	9.50	5.30	3.45	2.00	1.70	1.45	5.40	4.60
29	4.00	.....	4.40	11.30	9.25	5.20	3.35	1.95	1.70	1.45	5.25	4.65
30	4.00	.....	4.60	11.30	9.05	5.10	3.20	1.95	1.70	1.45	5.10	5.00
31	4.00	.....	4.65	.....	8.80	.....	.....	1.90	.....	1.45	.....	5.40

WENATCHEE STATION ON WENATCHEE RIVER.

This station is located on the Wenatchee River at the wagon bridge, 6 miles above its mouth and 7 miles from Wenatchee, Washington. It was established November 1, 1897. The rod is vertical and fastened to the face of the second wooden pier from the north. Observations of heights were taken at the bridge site of the Wenatchee Waterpower Company by C. Nasten, engineer in charge, 5 miles below the station, and reduced to the station gage by having simultaneous readings at both points on September 13, November 1, 14, and 20, respectively. Both banks of the river at the station are high and not liable to overflow. The bed of the river is composed of bowlders and the current is quite swift, even at low stages. The canal of the Wenatchee Waterpower Company is taken out about 1 mile above the station. The following are the discharge measurements made in 1897 by Cyrus C. Babb and C. Nasten:

September 13, gage height, 0.30 foot; discharge, 900 second-feet.
November 1, gage height, 0.00 feet; discharge, 706 second-feet.
November 14, gage height, 1.24 feet; discharge, 2,770 second-feet.
November 20, gage height, 5.10 feet; discharge, 13,280 second-feet.

Daily gage height, in feet, of Wenatchee River at Wenatchee, Washington, for 1897.

Day.	Aug.	Sept.	Oct.	Nov.	Day.	Aug.	Sept.	Oct.	Nov.	Day.	Aug.	Sept.	Oct.	Nov.
1	.....	.....	0.22	0.00	12	.....	.....	0.00	2.18	23	.....	0.36	0.20	.....
2	.....	.....	.15	.00	13	.....	0.30	.35	1.65	24	.....	.35	.....	.....
3	.....	.....	.....	.00	14	.....	.....	.30	1.25	25	.....	.52	.22	.....
4	.....	.....	.00	.00	15	.....	.....	.20	.....	26	0.82	.....	.12	.....
5	.....	.....	.00	.00	16	0.95	.15	.00	.....	27	.....	.38	.08	.....
6	.....	.....	.00	.00	17	.....	.15	.....	.....	28	.....	.38	.....	.....
7	1.22	.....	.00	.00	18	.....	.15	.00	.....	29	.....	.36	.00	.....
8	.....	0.45	.00	.....	19	.....	.....	.00	.....	30	.....	.30	.00	.....
9	.....	.....	.00	.....	20	.....	.25	.00	5.10	31	.....	.....	.....	.....
10	.....	.....	.....	.....	21	.....	.32	.00	.....					
11	.....	.....	.00	.....	22	.....	.35	.22	.....					

WHITMAN STATION ON WALLAWALLA RIVER.

This station, located on Wallawalla River, 7 miles below Wallawalla, Washington, was established July 19, 1897, for the purpose of determining the amount of water available for the several canals taken out below. The gage is an unusual form, consisting of a horizontal timber 4 inches square by 14 feet long, fastened to two vertical posts 6 feet apart and set in the ground at the edge of the bank of the river, with one end of the timber projecting out over the water. On this horizontal timber is then placed a wire gage. The distance from the end of the weight to the wire index is 19.62 feet and the outside edge of the pulley at the end of the timber is 4.27 feet from the zero. The bench mark is a nail driven into the southwest corner of the barn, 70 feet north of the gage, and 1 foot above the sill. Its elevation is 11.00 feet above datum. Discharge measurements are to be taken from a foot suspension bridge, near by. The channel is gravelly and the banks medium high. The observer is Mrs. W. F. York, post office, Wallawalla, Washington. A gaging on August 26,1897, was made by Sydney Arnold; gage height, 0.86 feet; discharge, 78 second-feet.

Daily gage height, in feet, of Wallawalla River at Whitman, Washington, for 1897.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	0.90	0.95	1.20	1.30	2.35	17	.....	0.88	1.15	1.25	1.90	2.55
2	.....	.88	.98	1.20	1.30	2.22	18	.....	.88	1.15	1.20	2.08	2.35
3	.....	.88	1.00	1.20	1.30	2.12	19	1.00	.82	1.15	1.20	2.32	2.20
4	.....	.88	1.00	1.20	1.30	2.02	20	1.00	.82	1.15	1.20	2.35	2.20
5	.....	.88	1.05	1.20	1.30	2.18	21	1.00	.88	1.15	1.20	2.28	2.15
6	.....	.88	1.15	1.20	1.30	2.35	22	1.00	.82	1.15	1.20	2.15	2.10
7	.....	.88	1.15	1.20	1.30	2.92	23	1.00	.82	1.15	1.25	2.15	2.05
8	.....	.88	1.20	1.20	1.30	3.05	24	1.00	.82	1.15	1.25	2.12	2.05
9	.....	.88	1.20	1.20	1.30	2.88	25	1.00	.82	1.15	1.25	2.05	2.05
10	.....	.88	1.18	1.20	1.38	2.68	26	.98	.82	1.15	1.25	1.98	2.12
11	.....	.88	1.15	1.20	1.95	2.80	27	.95	.82	1.15	1.30	1.90	2.25
12	.....	.88	1.15	1.20	1.90	2.88	28	.92	.82	1.15	1.30	1.85	2.75
13	.....	.88	1.15	1.22	2.05	2.80	29	.88	.82	1.15	1.30	1.85	3.20
14	.....	.88	1.15	1.30	2.02	3.00	30	.88	.85	1.20	1.30	2.20	3.75
15	.....	.88	1.15	1.30	1.92	2.88	31	.88	.90	.....	1.30	.....	3.28
16	.....	.88	1.15	1.25	1.90	2.72							

GIBBON STATION ON UMATILLA RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 361, is located about one-half mile west of the railroad station at Gibbon, Oregon. The lower section of the old gage rod was carried out by the floods in March, but a temporary rod was used until a permanent one was placed June 12, 400 feet downstream. It consists of a substantial rod 4 inches square by 14 feet long fastened to a rock by two one-half-inch bolts, soldered into holes, drilled into the rock. The bench mark for this new gage is a cross in black paint on the highest point of the rock to which the rod is fastened. Its elevation is 4.40 feet above datum, also marked on the rock. One foot in elevation on the rod is equal to 2.71 feet along its length. The section under the cable, at which discharge measurements were made, was also so modified by the March freshets that it was found necessary to remove the cable and car to a better location one-quarter of a mile below. The channel here is straight for a distance above and below. The bed of the river is gravelly. The initial point for soundings is on the right bank. The observer is W. Swart, telegraph operator at Gibbon. The following discharge measurements were made in 1897 by Cyrus C. Babb:

May 5, gage height, 4.10 feet; discharge, 2,141 second-feet.
May 22, gage height, 2.05 feet; discharge, 624 second-feet.
May 27, gage height, 1.36 feet; discharge, 448 second-feet.
June 7, gage height, 1.00 foot; discharge, 233 second-feet.
June 12, gage height, 0.80 foot; discharge, 168 second-feet.
July 5, gage height, 1.16 feet; discharge, 265 second-feet.
July 20, gage height, 0.59 foot; discharge, 118 second-feet.
August 27, gage height, 0.30 foot; discharge, 83 second-feet.

Daily gage height, in feet, of Umatilla River at Gibbon, Oregon, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.80	1.80	1.80	3.05	3.40	1.20	0.85	0.45	0.40	0.35	0.40	2.00
2	1.75	2.00	2.00	3.05	3.40	1.15	1.05	.45	.35	.35	.40	1.90
3	1.70	2.60	1.90	3.00	3.50	1.10	1.30	.45	.35	.35	.40	1.80
4	1.70	2.80	1.90	3.00	3.75	1.10	1.20	.45	.35	.35	.40	1.70
5	1.65	2.90	1.90	3.20	4.10	1.00	1.15	.45	.35	.35	.40	1.80
6	1.65	2.90	1.80	3.40	4.40	1.00	1.10	.45	.50	.35	.40	2.00
7	1.60	2.80	1.80	3.50	3.55	1.00	1.00	.45	.45	.35	.40	2.85
8	1.60	2.50	1.70	3.70	3.20	1.00	.95	.45	.45	.35	.45	2.90
9	1.60	2.40	1.70	4.00	3.00	.90	.90	.45	.40	.35	.50	2.60
10	1.60	2.90	1.60	5.00	3.00	.85	.85	.45	.40	.35	.80	2.60
11	1.55	2.80	1.55	4.90	3.10	.85	.80	.45	.40	.35	.90	2.50
12	1.55	2.90	1.55	4.80	3.10	.80	.80	.45	.40	.40	.95	2.50
13	1.55	3.10	1.50	4.70	3.20	.80	.75	.45	.35	.40	1.30	2.50
14	1.55	3.10	1.50	5.05	3.10	.80	.70	.45	.35	.40	1.20	2.45
15	1.55	2.95	1.50	5.38	3.05	1.10	.70	.40	.35	.40	1.05	2.20
16	1.50	2.80	1.60	5.50	3.00	1.25	.65	.40	.35	.40	1.05	1.90
17	1.50	2.50	1.70	6.00	3.15	1.15	.65	.40	.35	.35	1.20	1.70
18	1.50	2.40	1.70	6.05	2.90	1.10	.60	.40	.35	.35	2.00	1.70
19	1.70	2.20	1.70	5.65	2.60	1.00	.60	.35	.30	.35	1.90	1.70
20	1.65	2.20	1.65	4.70	2.40	.95	.60	.35	.30	.40	2.00	1.65
21	1.65	1.90	1.65	3.95	2.20	.95	.55	.35	.30	.40	1.30	1.50
22	1.65	1.80	1.65	3.70	2.02	.90	.55	.35	.30	.40	1.60	1.40
23	1.65	1.65	1.60	3.70	1.80	.85	.50	.35	.30	.40	1.60	1.40
24	1.60	1.60	3.05	3.60	1.85	.85	.50	.35	.30	.45	1.50	1.30
25	1.60	1.50	5.65	3.60	1.50	.85	.50	.35	.30	.45	1.40	1.25
26	1.60	1.60	5.05	4.40	1.35	1.00	.50	.35	.30	.40	1.30	1.80
27	1.60	1.60	4.20	4.40	1.25	.95	.45	.30	.35	.40	1.30	2.20
28	1.65	1.65	3.80	3.90	1.25	.90	.45	.30	.35	.40	1.20	2.80
29	1.65	.....	3.60	3.60	1.20	.85	.45	.30	.35	.40	1.40	3.50
30	1.70	.....	3.35	3.50	1.20	.85	.45	.30	.35	.40	2.00	3.70
31	1.75	.....	3.15	.....	1.20	.....	.45	.50	.....	.40	.....	3.40

MORO STATION ON DESCHUTES RIVER.

This station is located on the Deschutes River, near Moro, Oregon, 16 miles east of The Dalles, Oregon, at the ranch of the observer, J. E. Harris, 3 miles above what is known as the "free bridge." The rod is inclined. The bench mark is the head of a nail, at elevation 8.41 feet, in the large alder tree to which the rod is spiked. The discharge measurements are taken at the iron bridge below. The section here is poor, owing to the swift current. The bed is rocky and uneven. A measurement made on September 27, 1897, by Cyrus C. Babb, gave gage height, 2.10 feet; discharge, 5,962 second-feet.

Daily gage height, in feet, of Deschutes River at Moro, Oregon, for 1897.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1	.....	2.00	2.20	12	.....	2.50	3.40	23	2.10	2.50	2.50
2	.....	2.00	2.20	13	.....	2.50	3.20	24	2.00	2.40	2.40
3	.....	2.00	2.10	14	.....	2.40	4.10	25	2.00	2.30	2.40
4	.....	2.00	2.10	15	.....	2.40	3.40	26	2.00	2.30	2.40
5	.....	2.10	2.10	16	.....	2.40	3.20	27	2.00	2.20	2.80
6	.....	2.20	2.30	17	.....	2.50	3.10	28	2.00	2.20	2.70
7	.....	2.30	3.30	18	.....	2.60	3.00	29	2.00	2.20	3.10
8	.....	2.30	3.40	19	2.00	2.80	2.80	30	2.00	2.10	3.00
9	.....	2.30	3.40	20	2.10	3.10	2.60	31	2.10	2.10	2.10
10	.....	2.40	3.20	21	2.00	2.80	2.60				
11	.....	2.40	3.20	22	2.10	2.50	2.50				

TUCKERS STATION ON HOOD RIVER.

This station is located at Tuckers, 5 miles south of Hood River, Oregon. It was established October 20, 1897, by Cyrus C. Babb. The gage is of the wire type. The rod is nailed to a wooden member of the bridge. The length of the gage wire is 33.85 feet, and the pulley is 2 feet from end of rod. At gage height 1.50 the water is 30.10 feet below edge of floor at side of inner inclined wooden brace at station 4.5 feet from east end, lower side. The bottom is a rock ledge and the sides are precipitous. The observer is B. R. Tucker, proprietor of a sawmill. Measurements were made as follows in 1897 by Cyrus C. Babb:

September 28, gage height, 1.70 feet; discharge, 541 second-feet.
October 20, gage height, 1.50 feet; discharge, 459 second-feet.

Daily gage height, in feet, of Hood River at Tuckers, Oregon, for 1897.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1	.....	1.60	3.40	12	.....	5.20	5.10	23	1.80	3.50	2.90
2	.....	1.50	3.00	13	.....	5.70	5.00	24	1.90	3.10	2.90
3	.....	1.50	2.80	14	.....	3.80	6.50	25	1.80	2.90	3.40
4	.....	1.50	2.70	15	.....	3.20	5.40	26	1.70	2.90	4.00
5	.....	1.70	6.70	16	.....	3.00	5.00	27	1.60	2.60	5.00
6	.....	1.80	7.50	17	.....	4.20	4.50	28	1.60	2.50	8.97
7	.....	1.60	7.30	18	.....	9.00	3.90	29	1.60	2.70	7.60
8	.....	1.70	7.00	19	.....	7.80	3.90	30	1.60	4.00	6.00
9	.....	2.10	5.50	20	1.50	5.60	3.50	31	1.60		5.40
10	.....	4.60	5.00	21	1.90	5.20	3.50				
11	.....	4.80	4.90	22	1.80	4.10	3.10				

SEGUIN STATION ON DUNGENESS RIVER.

This station is located at a county bridge near Seguin Post-office, 18 miles southeast of Port Angeles, Washington, and 9 miles above the mouth of the river. It was established July 5, 1897, by A. Judson Adams. The gage consists of a vertical rod fastened to the downstream side of the crib abutment on the right bank of the river. The bench mark is a spike in the root of a fir stump 4 feet in diameter, about 20 feet north of north end of bridge, the elevation being 12.75 feet above gage datum. The initial point for sounding is on the right bank. The channel is straight for some distance above and below the station. The right bank is high and not liable to overflow. The left bank is low and is flooded during freshets. The observer is David Duncan, farmer. Discharge measurements were made as follows by A. Judson Adams in 1897:

July 5, gage height, 5.06 feet; discharge, 546 second-feet.
August 17, gage height, 4.81 feet; discharge, 357 second-feet.
November 4, gage height, 4.36 feet; discharge, 165 second-feet.

Daily gage height, in feet, of Dungeness River at Seguin, Washington, for 1897.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	4.70	4.60	4.30	4.50	4.20	17	4.95	4.80	4.35	4.20	5.80	4.20
2	.....	4.70	4.50	4.25	4.40	5.20	18	4.90	4.80	4.40	4.20	8.10	4.10
3	.....	4.70	4.55	4.25	4.40	5.10	19	4.90	4.85	4.40	4.20	6.60	4.00
4	.....	4.75	4.55	4.30	4.35	5.10	20	5.00	4.85	4.30	4.30	5.90	4.00
5	5.05	4.80	4.50	4.25	4.35	5.70	21	4.95	4.90	4.35	4.25	5.70	3.90
6	5.10	4.80	4.50	4.25	4.40	6.25	22	4.90	4.80	4.40	4.75	5.50	3.90
7	5.05	4.80	4.40	4.20	4.40	7.40	23	4.90	4.80	4.40	5.05	5.40	3.90
8	5.00	4.80	4.40	4.20	4.30	6.10	24	4.90	4.75	4.40	4.70	5.35	3.95
9	5.00	4.80	4.40	4.20	4.40	5.50	25	4.85	4.70	4.40	4.60	5.30	3.90
10	5.00	4.80	4.35	4.25	4.85	5.20	26	4.80	4.55	4.40	4.50	5.20	3.80
11	5.10	4.80	4.35	4.30	5.05	5.20	27	4.80	4.55	4.40	4.50	5.20	7.90
12	5.20	4.75	4.35	4.40	5.05	5.00	28	4.80	4.60	4.40	4.45	5.10	5.80
13	5.05	4.70	4.40	4.30	4.85	8.00	29	4.80	4.55	4.40	4.45	5.20	5.50
14	5.05	4.70	4.40	4.25	4.85	5.20	30	4.80	4.55	4.35	4.45	5.30	5.00
15	5.05	4.70	4.40	4.20	4.60	4.60	31	4.75	4.75	.....	4.40	.....	4.80
16	5.00	4.80	4.35	4.20	4.60	4.35							

McDONALD STATION ON ELWHA RIVER.

This station is located 9 miles southwest of Port Angeles at McDonald, Clallam County, Washington, at the new county bridge and was established October 8, 1897, by A. Judson Adams. The horizontal rod of the wire gage is nailed to the railing of the north side of the bridge, the 9-foot mark being opposite the fourth upright post counting from the east end of the bridge. The length of the gage wire is 49.26 feet, and the distance from the end of the rod to outside edge of pulley is 7.92 feet. The bench mark is the top edge of the top side-rail on the north side of the bridge at the third upright post from the east end of the bridge, and its elevation is 41.34 feet above gage datum. The initial point for soundings is on the right bank. The channel is straight for some distance above and below the station. Both banks are high and rocky and will not overflow. The bed of the stream is rocky. The observer is Thomas H. Stringham, postmaster at McDonald. The following measurements of discharge were made by A. Judson Adams in 1897:

October 8, gage height, 0.95 foot; discharge, 406 second-feet.
December 28, gage height, 8.00 feet; discharge, 4,623 second-feet.

Daily gage height, in feet, of Elwha River at McDonald, Washington, for 1897.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1	.....	1.20	2.40	12	1.10	2.40	3.45	23	2.50	2.55	2.00
2	.....	1.15	2.00	13	1.22	2.20	3.60	24	1.60	2.35	2.10
3	.....	1.15	1.45	14	.95	2.15	4.60	25	1.35	2.10	2.35
4	.....	1.20	2.50	15	.90	2.05	3.80	26	1.35	1.95	2.55
5	.....	1.25	2.85	16	.85	1.95	3.20	27	1.30	1.90	6.90
6	.....	1.22	4.50	17	.85	2.05	3.50	28	1.30	1.45	8.95
7	.....	1.22	6.40	18	.80	14.50	2.50	29	1.25	2.50	6.87
8	1.00	1.25	5.20	19	1.25	5.40	2.45	30	1.25	2.90	4.55
9	1.00	3.30	4.30	20	1.45	4.00	2.40	31	1.20	.....	.....
10	1.00	2.45	4.25	21	2.65	3.30	2.50				
11	1.00	3.60	3.95	22	2.20	3.05	2.10				

FORKS STATION ON CALOWA RIVER.

This station is located at the county highway bridge in the southwestern part of Clallam County near Forks, Washington, and is reached by steamer to Clallam Bay, thence overland 30 miles by wagon. It was established November 12, 1897, by A. Judson Adams. The horizontal rod of the wire gage is nailed to the railing of the wagon bridge. Both banks are high and rocky and do not overflow. The bed of the stream is gravelly. The observer is H. C. Whittier, a farmer, post-office, Forks, Washington. The following discharge measurements were made by A. Judson Adams in 1897:

September 6, gage height, —— feet; discharge, 467 second-feet.
November 12, gage height, 3.66 feet; discharge 1,494 second-feet.

Daily gage height, in feet, of Calowa River at Forks, Washington, for 1897.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1	.....	4.00	9	.....	6.45	17	10.60	3.75	25	3.00	3.95
2	.....	3.80	10	.....	6.50	18	17.00	3.30	26	2.15	4.70
3	.....	3.00	11	.....	7.10	19	7.25	2.90	27	3.00	15.90
4	.....	3.85	12	3.85	5.70	20	5.00	2.70	28	2.80	10.50
5	.....	6.70	13	3.90	10.25	21	4.70	2.55	29	3.00	6.65
6	.....	6.45	14	3.40	8.00	22	4.05	2.40	30	6.40	5.00
7	.....	9.60	15	2.95	5.40	23	5.55	2.35	31	.....	4.10
8	.....	9.40	16	2.70	4.30	24	3.10	2.40			

QUILLAYUTE STATION ON SOLDUCK RIVER.

This station is located at the county highway bridge about 9 miles northeast of Lapush, in southwestern part of Clallam County, near Quillayute, Washington, and was established November 13, 1897, by A. Judson Adams. The horizontal rod of the wire gage is fastened to the railing of the wagon bridge. The channel is straight for some distance above and below the station. The banks are high and rocky and do not overflow. The bed of the stream is composed of rocks and gravel. The observer is Peter Van Bossche, a farmer, address Quillayute, Washington. The following measurements were made by A. Judson Adams in 1897:

September 7, gage height, —— feet; discharge, 858 second-feet.
November 13, gage height, 4.00 feet; discharge, 1,898 second-feet.

Daily gage height, in feet, of Solduck River at Quillayute, Washington, for 1897.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1	.....	4.95	9	.....	7.15	17	3.95	4.75	25	3.75	4.20
2	.....	4.30	10	.....	6.45	18	11.90	4.35	26	3.65	4.60
3	.....	3.90	11	.....	7.10	19	8.35	4.05	27	3.60	9.80
4	.....	3.65	12	.....	6.35	20	5.90	3.80	28	3.40	14.30
5	.....	6.80	13	4.00	7.55	21	5.40	3.60	29	3.50	8.40
6	.....	5.45	14	3.45	8.90	22	4.90	3.45	30	5.55	6.35
7	.....	9.10	15	3.10	6.30	23	4.40	3.30	31	.....	5.50
8	.....	8.95	16	2.90	5.40	24	4.00	3.30			

JELLYS FERRY STATION ON SACRAMENTO RIVER.

This station, as described in the Eighteenth Annual Report, Part IV, page 365, is located about 12 miles above the town of Redbluff, California, at a crossing of a county road at Jellys Ferry. The observer, Fred Lemstrom, is the ferryman. The ferry cable is used in the discharge measurements. The gage consists of a vertical rod marked to tenths of a foot. It is made in three sections and nailed firmly to trees. Besides the gage rod at this point, another rod is located 1,206 feet upstream from the gage and another 350 feet downstream, in order to determine the slope of the water surface. Bench mark No. 1 is on an oak tree on the left bank 1,206 feet upstream from the ferry and 65 feet north of the upper rod, and is 22.724 feet above gage datum. Bench mark No. 2 is on an oak tree on the left bank of the river 300 feet below the cable, and is 22.429 feet above gage datum. The channel for 1,000 feet above and below the station is nearly straight. The right bank is high, but the left bank is liable to overflow when the water rises above the 25-foot mark. The bed of the stream consists of gravel, and changes slightly. The following discharge measurements were made in 1897 by J. B. Lippincott and Fred Lemstrom:

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec. ft.*		*Feet.*	*Sec. ft.*		*Feet.*	*Sec. ft.*
Mar. 13...	10.30	18,568	June 28 ...	6.42	6,493	Oct. 28...	5.70	4,202
Mar. 29...	14.40	28,319	July 13....	5.95	5,032	Nov. 13 ..	5.70	4,196
Apr. 3...	10.85	21,519	July 28....	5.70	5,082	Nov. 28 ..	5.95	6,179
Apr. 16...	12.20	25,806	Aug. 13....	5.60	4,285	Dec. 13...	7.40	10,151
Apr. 30...	10.30	18,544	Aug. 28....	5.50	4,490	Dec. 17...	6.85	8,195
May 14...	9.00	14,719	Sept. 13 ...	5.50	4,257	Dec. 17...	6.85	8,802
May 28...	7.50	10,193	Sept. 28 ...	5.50	4,418	Dec. 28...	5.95	6,105
June 11 ..	6.50	7,277	Oct. 13	5.60	4,591			

REDBLUFF STATION.

This station, as described in the Eighteenth Annual Report, Part IV, page 362, is located at the wagon bridge in the town of Redbluff, California. The observations of gage heights are maintained by the Weather Bureau and are taken by Maurice Connell. The vertical rod, 30 feet long, is nailed to a large sycamore tree on the left bank of the river about 25 feet above the bridge.

Daily gage height, in feet, of Sacramento River at Jellys Ferry, California, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	13.10	19.75	16.45	12.65	10.20	7.15	6.25	5.70	5.50	5.50	5.70	5.90
2	11.25	19.20	13.45	11.35	10.05	7.10	6.20	5.70	5.50	5.60	5.70	5.90
3	10.25	18.70	12.35	10.85	9.90	7.00	6.20	5.70	5.50	5.60	5.70	5.80
4	9.50	20.53	11.60	10.55	9.90	6.95	6.20	5.70	5.50	5.50	5.70	5.80
5	9.00	23.77	11.90	10 50	9.95	6.90	6.15	5.60	5.50	5.50	5.70	5.80
6	8.65	22.60	11.75	10.70	9.95	6.80	6.10	5.60	5.50	5.50	5.70	6.00
7	8.45	20.30	12.20	11.20	9.60	6.70	6.10	5.60	5.50	5.50	5.70	6.50
8	8.25	16.90	11.95	11.25	9.25	6.70	6.10	5.60	5.50	5.50	5.70	9.70
9	8.05	15.40	11.75	11.35	9.00	6.60	6.10	5.60	5.50	5.50	5.70	7.80
10	7.85	14.00	11.20	11.55	8.95	6.50	6.00	5.60	5.50	5.50	5.70	7.20
11	7.75	12.75	10.60	12.00	9.20	6.50	6.00	5.60	5.50	5.50	5.70	8.40
12	7.60	12.25	10.30	12.05	9.05	6.50	6.00	5.60	5.50	5.50	5.70	8.30
13	7.65	11.55	9.85	12.00	9.05	6.40	6.00	5.60	5.50	5.60	5.70	7.40
14	7.60	11.15	9.55	11.95	9.00	6.40	5.90	5.60	5.50	5.60	5.70	8.90
15	7.50	11.00	9.45	12.10	8.85	6.55	5.90	5.60	5.50	5.60	5.70	7.60
16	7.40	13.10	9.65	12.20	8.80	6.50	5.90	5.60	5.50	5.60	5.70	7.20
17	7.25	12.00	9.75	12.15	8.65	6.40	5.90	5.60	5.50	5.60	5.70	6.80
18	7.10	11.30	9.60	12.25	8.50	6.30	5.80	5.50	5.50	5.60	5.70	6.60
19	7.00	13.90	9.55	12.45	8.30	6.35	5.80	5.50	5.50	5.60	5.70	6.50
20	7.00	13.20	9.55	13.05	8.30	6.80	5.80	5.50	5.50	5.60	6.10	6.40
21	6.95	11.55	9.10	12.10	8.20	7.20	5.80	5.50	5.50	5.70	6.30	6.30
22	6.90	10.65	8.85	11.55	8.10	6.95	5.80	5.50	5.50	5.70	6.00	6.10
23	6.90	10.15	8.65	11.15	8.00	6.85	5.80	5.50	5.50	6.00	7.00	6.10
24	6.95	9.85	8.50	10.85	8.00	6.65	5.80	5.50	5.50	6.30	6.60	6.10
25	7.00	9.90	8.70	10.80	7.90	6.55	5.80	5.50	5.50	5.80	6.30	6.00
26	6.90	10.00	10.15	11.00	7.70	6.50	5.70	5.50	5.50	5.80	6.10	6.00
27	6.90	10.10	10.10	11.20	7.50	6.50	5.70	5.50	5.50	5.70	6.00	5.90
28	7.45	10.00	15.90	11.00	7.45	6.40	5.70	5.50	5.50	5.70	5.90	5.90
29	17.45	.....	14.55	10.65	7.30	6.40	5.70	5.50	5.50	5.70	5.90	5.90
30	13.95	.....	13.10	10.30	7.30	6.30	5.70	5.50	5.50	5.70	5.90	5.90
31	13.80	.....	12.15	.....	7.20	.....	5.70	5.50	.....	.....	.....	5.90

Daily gage height, in feet, of Sacramento River at Redbluff, California, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.2	16.0	13.6	7.9	6.0	2.3	1.0	0.1	0.6	0.0	0.3	0.4
2	6.1	15.6	11.0	7.6	6.1	2.3	1.0	.1	.7	.2	.3	.4
3	5.7	14.0	8.6	7.4	6.9	2.3	1.0	.1	.3	.3	.5	.6
4	5.2	17.7	8.0	6.5	6.8	2.0	1.0	.1	.2	.2	.5	.7
5	4.9	20.7	7.8	6.1	6.6	2.0	1.0	.1	.1	.1	.5	1.3
6	4.4	21.6	7.8	6.1	6.3	2.0	.9	.1	.1	.1	.4	3.2
7	4.3	15.5	7.0	5.8	5.9	1.9	.9	.1	.1	.1	.3	3.4
8	4.1	13.2	6.0	7.1	5.0	1.9	.9	.1	.1	.1	.3	7.2
9	3.9	11.6	7.6	7.0	5.0	1.7	.9	.1	.1	.1	.3	6.5
10	3.6	10.0	6.0	7.4	5.0	1.7	.8	.1	.1	.0	.3	5.3
11	3.4	9.6	6.0	7.8	5.0	1.6	.7	.1	.1	.0	.3	4.4
12	3.0	8.6	6.0	8.0	5.0	1.5	.7	.1	.1	.1	.3	5.0
13	3.2	7.5	5.6	8.0	4.9	1.3	.7	.1	.1	.3	.3	4.9
14	3.0	7.0	5.2	7.8	4.9	1.0	.6	.1	.1	.5	.3	3.9
15	3.1	7.1	5.0	8.0	4.8	1.0	.5	.1	.1	.4	.3	4.0
16	2.4	8.5	5.0	8.0	4.6	1.0	.5	.1	.1	.3	.4	2.0
17	2.2	8.2	5.3	8.1	4.3	1.0	.5	.1	.1	.2	.4	1.9
18	2.1	7.4	5.3	8.1	4.2	1.0	.3	.1	.0	.1	.6	1.6
19	2.0	10.0	5.1	8.1	4.2	1.8	.3	.1	.0	.1	.8	1.6
20	2.0	11.0	4.9	8.0	4.0	2.0	.2	.1	.0	.2	1.0	1.4
21	2.0	7.6	4.6	8.0	4.0	2.9	.2	.1	.0	.4	1.3	1.0
22	2.0	6.7	5.0	8.0	4.0	1.9	.2	.1	.0	1.0	1.4	1.0
23	2.0	6.0	5.2	7.6	4.1	2.0	.1	.1	.0	1.2	.9	1.0
24	2.0	5.9	6.1	7.4	4.1	2.0	.1	.1	.0	1.0	.9	1.0
25	2.0	5.8	6.1	7.1	4.1	1.4	.1	.1	.0	1.0	.4	1.0
26	2.0	5.9	8.6	7.0	4.1	1.4	.1	.1	.0	.8	.4	1.0
27	2.0	5.6	10.7	6.9	3.8	1.0	.1	.1	.0	.7	.4	1.0
28	2.4	6.9	9.0	6.8	3.7	1.0	.1	.0	.0	.6	.4	1.0
29	14.0	.....	8.6	6.6	3.7	1.0	.1	.0	.0	.5	.4	1.0
30	11.1	.....	8.1	6.0	3.7	1.0	.1	.0	.0	.5	.4	1.0
31	10.0	.....	8.4	.....	3.7	.....	.1	.0	.....	.3	.....	.9

OAKDALE STATION ON STANISLAUS RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 371, is located at the wagon bridge one-half mile north of the town of Oakdale, California. One gage rod is set between the south or left hand piers of the wagon bridge on the side toward the water, and can be read from the bridge. The datum is 27.92 feet below the top of the southeast iron pier of the wagon bridge. A rod for the lowest readings of the river is 125 feet below the wagon bridge on the left bank and referred to the same datum. A secondary gage for determining the slope of the river is attached to the crib abutment of the Southern Pacific Railroad bridge, 1,071 feet below the wagon bridge and referred to the same datum as the upper gage. Its zero is 5.92 feet below the top of the cap on the piles of the south crib pier of the railroad bridge. This pier has settled during the last year. The channel of the river is uniform and straight above and below the station, and both banks are high enough to prevent overflow in all except extreme conditions of flood. The bed of the stream at this point is of sand and gravel and changes only slightly. The observer is Frank Templin. The following discharge measurements were made in 1897 by J. B. Lippincott and A. Q. Campbell:

February 16, gage height, 4.22 feet; discharge, 1,346 second-feet.
May 30, gage height, 8.60 feet; discharge, 6,754 second-feet.
July 14, gage height, 3.20 feet; discharge, 1,015 second-feet.
September 5, gage height, 2.00 feet; discharge, 144 second-feet.
October 29, gage height 2.40 feet; discharge, 223 second-feet.
December 19, gage height 3.00 feet; discharge, 429 second-feet.

Daily gage height, in feet, of Stanislaus River at Oakdale, California, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.60	8.66	5.00	5.60	8.40	6.60	3.80	2.40	2.20	1.90	2.20	2.50
2	3.30	8.52	4.70	5.00	9.53	6.20	3.90	2.40	2.20	2.00	2.20	2.50
3	3.10	6.10	4.60	4.90	10.11	6.00	4.00	2.40	2.10	2.00	2.30	2.50
4	3.10	11.20	4.50	4.80	10.80	6.00	3.90	2.40	2.10	2.00	2.30	2.40
5	3.00	9.50	4.40	4.90	10.50	5.90	3.80	2.30	2.00	2.00	2.20	2.40
6	3.00	10.00	4.90	5.10	9.53	5.90	3.80	2.30	2.00	2.00	2.20	2.30
7	3.00	6.90	5.50	5.50	8.80	6.00	3.70	2.30	2.00	2.00	2.30	2.40
8	3.00	6.20	5.10	5.60	8.20	6.40	3.50	2.30	2.00	2.00	2.30	2.70
9	3.00	5.50	4.90	5.90	8.50	6.50	3.50	2.30	2.00	2.00	2.20	4.40
10	3.00	5.10	4.00	6.50	8.40	5.80	3.30	2.30	2.00	2.00	2.20	3.40
11	2.90	4.80	4.40	7.00	9.20	5.40	3.10	2.30	2.00	2.00	2.20	3.10
12	2.90	4.80	4.30	7.40	9.42	5.10	3.20	2.20	2.00	2.00	2.30	3.00
13	3.00	4.50	4.30	7.60	9.13	5.20	3.20	2.20	2.00	2.00	2.30	3.40
14	3.83	4.30	4.10	8.20	9.07	5.40	3.20	2.20	2.00	2.00	2.20	3.60
15	3.10	4.20	4.10	8.70	8.77	4.90	3.20	2.20	2.00	2.20	2.20	3.20
16	3.00	4.10	4.10	9.20	8.62	4.50	3.20	2.10	2.00	2.30	2.20	3.00
17	2.90	6.07	4.40	9.80	8.45	4.10	3.20	2.10	1.90	2.20	2.20	2.90
18	2.90	5.00	5.15	10.30	8.20	3.90	3.00	2.10	2.00	2.10	2.20	2.80
19	2.90	5.47	5.13	9.00	8.90	3.90	2.90	2.10	1.90	2.10	2.20	2.80
20	2.90	5.63	4.60	7.90	9.53	3.90	2.80	2.20	1.90	2.10	2.20	2.60
21	2.90	5.00	4.50	7.20	9.03	4.10	2.80	2.30	1.90	2.10	2.10	2.80
22	2.90	4.60	4.30	7.20	9.23	4.00	2.80	2.30	1.90	2.20	3.00	2.70
23	2.90	4.40	4.30	6.80	10.60	3.90	2.70	2.20	1.90	2.20	3.10	2.60
24	2.90	4.30	4.30	6.80	10.10	3.90	2.70	2.20	2.00	2.40	3.50	2.40
25	2.90	4.30	4.50	7.50	9.10	3.90	2.60	2.20	2.00	2.50	3.00	2.70
26	2.90	4.40	4.80	8.70	8.00	3.90	2.60	2.20	2.00	2.40	2.80	2.60
27	2.90	4.50	4.80	9.20	8.00	3.70	2.50	2.20	2.00	2.30	2.60	2.50
28	2.90	5.50	7.40	9.60	8.20	3.60	2.50	2.20	2.00	2.30	2.50	2.80
29	5.15	.....	6.00	8.90	8.20	3.70	2.50	2.20	2.00	2.30	2.40	2.90
30	4.53	.....	5.40	8.80	8.00	3.80	2.50	2.20	1.90	2.20	2.40	2.70
31	4.40	.....	5.10	.....	7.70	.....	2.50	2.20	.....	2.20	.....	2.70

LAGRANGE STATION ON TUOLUMNE RIVER.

This station, described in the Eighteeenth Annual Report, Part IV, page 378, is located at the bridge in the town of Lagrange, California, 32 miles from Modesto. The vertical gage rod is fastened to timbers between the two iron piers on the right bank of the river. The bench mark is a nail driven into the bottom of the west post of the fifth bent south of the south iron cylinder and is 15.31 feet above the zero of the rod. The channel both above and below the bridge is straight for several hundred feet and the velocity of the stream is quite uniform. Both banks are high and not subject to overflow. The bed is of gravel. The observer is Cleo Pereira. The following is a list of discharge measurements made by J. B. Lippincott and A. Q. Campbell in 1897:

February 15, gage height, 5.80 feet; discharge, 1,864 second-feet.
May 29, gage height, 9.25 feet; discharge, 11,594 second-feet.
July 12, gage height, 5.70 feet; discharge, 1,839 second-feet.
September 7, gage height, 4.00 feet; discharge, 95 second-feet.
October 30, gage height, 4.73 feet; discharge, 534 second-feet.
December 20, gage height, 4.85 feet; discharge 614 second-feet.

Daily gage height, in feet, of Tuolumne River at Lagrange, California, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.55	8.95	6.30	6.50	8.70	8.30	6.60	4.70	4.10	3.80	4.70	5.30
2	5.25	8.85	6.40	6.40	8.90	8.00	6.70	4.60	4.10	3.80	4.70	5.10
3	5.15	9.05	6.40	6.30	9.30	7.90	6.80	4.60	4.10	3.80	4.80	5.00
4	5.20	9.80	6.20	6.40	9.60	8.00	6.80	4.50	4.00	3.80	4.70	4.90
5	5.10	8.95	6.10	6.60	9.70	8.00	6.90	4.50	4.00	3.90	4.70	4.90
6	5.10	8.10	6.80	6.90	9.80	8.20	6.70	4.50	4.00	3.90	4.60	4.80
7	5.10	8.30	6.80	7.00	9.90	8.50	6.50	4.50	4.00	3.90	4.70	4.80
8	5.10	7.10	6.30	7.20	9.50	8.20	6.20	3.80	4.00	3.80	4.60	6.60
9	5.10	6.90	6.30	7.30	9.80	8.20	6.00	4.80	3.90	3.80	4.60	6.30
10	5.00	6.35	6.20	7.40	9.70	8.50	6.40	4.50	4.00	3.80	4.60	5.90
11	5.00	6.20	6.20	7.60	9.00	8.00	6.30	4.50	4.00	4.70	4.60	5.60
12	5.00	6.20	6.10	7.90	9.30	7.60	6.10	4.50	4.00	4.00	4.60	5.80
13	5.05	6.20	6.10	8.20	9.20	7.50	6.20	4.30	4.00	3.80	4.70	5.70
14	5.40	5.95	6.00	8.50	9.10	7.30	5.80	4.30	3.90	3.90	4.60	5.40
15	5.10	5.80	6.00	8.90	9.70	7.00	5.60	4.30	3.90	3.90	4.60	5.50
16	5.10	5.70	6.00	9.30	9.00	6.90	5.50	4.30	3.90	4.40	4.60	5.30
17	5.10	7.00	6.00	9.60	8.80	6.40	5.40	4.10	3.80	4.80	4.80	5.10
18	5.00	6.90	6.70	9.80	8.60	6.20	5.40	4.10	3.80	4.70	4.50	5.10
19	4.90	6.70	7.80	9.90	8.90	6.00	5.40	4.20	3.90	4.30	4.50	5.00
20	4.90	6.80	6.50	8.70	9.20	6.30	5.50	4.30	3.40	3.80	4.40	5.40
21	4.90	6.50	6.60	8.60	9.60	6.40	5.40	4.30	3.40	3.90	6.40	4.80
22	4.95	6.30	6.20	8.40	10.00	6.50	5.30	4.20	3.50	3.90	6.40	4.80
23	5.00	6.10	6.10	8.30	10.10	6.40	5.20	4.20	3.60	3.90	5.70	4.80
24	5.00	6.00	6.30	8.10	10.20	6.20	5.00	4.10	3.80	5.00	5.10	4.80
25	5.00	6.00	6.40	7.50	10.30	6.40	5.00	4.10	3.80	4.70	5.20	4.80
26	5.35	6.20	6.70	7.80	9.00	6.50	4.90	4.10	3.80	4.50	5.20	4.80
27	5.45	6.30	6.70	7.90	9.20	6.50	5.00	4.20	3.80	4.50	5.00	4.80
28	6.40	6.30	9.00	8.20	9.10	6.60	4.90	4.10	3.80	4.50	5.00	4.80
29	6.40	.....	8.70	8.30	9.20	6.70	4.80	4.20	3.80	4.50	5.00	4.80
30	6.55	.....	7.40	8.50	9.30	6.70	4.90	4.10	3.80	4.70	5.00	4.80
31	6.20	.....	6.60	.....	9.00	.....	4.70	4.10	.....	4.70	.....	4.80

MODESTO STATION ON TUOLUMNE RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 384, is located one-half mile south of the depot and at the wagon-road bridge at Modesto, California. The gage is a vertical rod 2 by 6 inches, fastened on the south side of the central railroad pier. The top of the rail at the central pier is 46.05 feet above the datum of the gage. The discharge measurements are made from the wagon bridge, 100 feet west of the railroad bridge. The initial point for sounding is at the pier on the right bank. The channel above and below the station is straight, but in the summer stages of the stream the current is very sluggish. The right bank shows indications of overflow. The observer is J. T. Reed. No discharge measurements were made in 1897.

Daily gage height, in feet, of Tuolumne River at Modesto, California, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.50	11.97	7.42	7.92	13.42	14.37	8.17	4.66	3.70	3.13	4.12	4.58
2	5.63	18.00	8.38	8.25	13.46	13.00	8.42	4.58	3.66	3.21	4.25	4.75
3	5.17	11.79	7.58	7.50	12.33	11.96	8.58	4.54	3.58	3.25	4.37	4.58
4	4.83	9.17	7.46	7.46	14.17	12.04	8.62	4.50	3.54	3.25	4.08	4.54
5	4.79	13.88	6.96	7.71	15.92	12.08	8.17	4.46	3.50	3.17	4.33	4.50
6	4.71	19.25	7.83	7.88	16.54	12.25	7.70	4.37	3.46	3.13	4.12	4.25
7	4.63	12.25	9.83	8.46	16.35	12.62	7.54	4.29	3.38	3.25	4.12	4.48
8	4.67	12.50	8.17	8.92	15.08	12.83	7.12	4.21	3.38	3.17	4.04	4.21
9	4.58	9.29	7.50	9.21	14.54	12.43	6.75	4.12	3.33	3.29	4.04	9.66
10	4.56	8.25	7.25	9.83	13.33	12.08	6.58	4.08	3.33	3.25	4.04	7.33
11	4.48	7.63	7.13	10.46	13.29	12.17	6.50	4.08	3.33	3.21	3.96	6.12
12	4.44	7.33	6.83	11.21	14.29	10.87	6.50	4.17	3.33	3.29	4.08	5.62
13	4.19	7.13	6.63	11.83	15.00	10.66	6.87	4.17	3.25	3.37	4.04	5.54
14	4.75	6.92	6.54	11.96	15.21	11.25	6.83	4.08	3.25	3.37	3.96	6.04
15	5.79	6.46	6.46	11.50	15.79	10.92	6.83	3.96	3.25	3.29	4.12	5.87
16	5.04	6.46	6.54	12.96	15.04	9.42	6.58	3.92	3.25	3.37	4.12	5.58
17	4.88	8.83	6.73	13.54	14.67	8.83	6.70	3.92	3.17	3.62	4.04	5.17
18	4.56	8.63	7.42	14.21	14.04	8.33	6.37	3.83	3.17	3.79	3.92	5.00
19	4.46	8.88	9.86	14.25	13.58	7.92	6.54	3.83	3.17	3.96	3.87	4.87
20	4.38	9.78	8.04	13.04	14.79	7.66	5.83	3.92	3.25	3.87	3.83	4.54
21	4.29	8.58	7.50	11.42	15.79	8.08	5.83	3.83	3.25	3.66	2.92	4.46
22	4.21	7.71	7.08	11.08	16.33	8.12	5.42	3.83	3.17	3.58	8.08	4.37
23	4.13	7.42	6.75	10.50	17.29	8.04	5.25	3.83	3.17	3.54	7.87	4.50
24	4.17	7.21	6.81	9.92	17.75	8.12	5.17	3.96	3.17	3.37	7.08	4.50
25	4.17	7.00	7.08	9.83	17.92	8.17	5.12	4.08	3.17	3.96	7.29	4.33
26	4.13	7.00	7.67	10.83	16.96	8.04	5.00	4.17	3.13	4.50	6.25	4.25
27	4.13	7.25	7.88	11.92	15.46	7.42	4.96	3.96	3.17	4.42	5.58	4.12
28	4.04	7.50	7.75	13.21	14.54	7.58	4.88	3.87	3.17	4.42	5.12	4.04
29	8.45	.....	12.67	13.42	15.08	7.66	4.79	3.79	3.17	4.25	5.04	4.04
30	6.50	.....	9.42	13.25	15.00	7.92	4.75	3.75	3.17	4.12	4.75	4.04
31	6.54	.....	8.25	.....	15.04	.....	4.66	3.75	.....	4.08	.....	4.04

HERNDON STATION ON SAN JOAQUIN RIVER.

This station, as described in the Eighteenth Annual Report, Part IV, page 385, is located at the wagon bridge half a mile north of Herndon and 12 miles north of Fresno, California, on the Southern Pacific Railroad. The gage consists of a vertical rod fastened to the lower side of the south central railroad bridge pier. The bench mark is at the south end of the wagon bridge trestle on the west side, on a nail in a post 0.2 of a foot above the ground and marked by a "B. M." cut in the post. The elevation above rod datum is 24.12 feet. A gage on the same datum is also painted on the southwest cylinder. The initial point for soundings is on the left bank at the south cylinder. The channel for 900 feet above and 3,000 feet below the bridge is straight and the water has a uniform and moderate velocity. There are no piers in the bed of the stream to disturb the current and the section is a satisfactory one. The right bank is high, rocky, and steep. The bed of the stream is sandy and gravelly. The observer is G. G. Nelson. The following discharge measurements were made by J. B Lippincott and A. Q. Campbell in 1897:

February 14, gage height, 3.58 feet; discharge, 1,117 second-feet.
May 31, gage height, 8.60 feet; discharge, 10,774 second-feet.
July 16, gage height, 4.50 feet; discharge, 3,223 second-feet.
September 8, gage height, 2.66 feet; discharge, 271 second-feet.
November 2, gage height, 2.92 feet; discharge, 515 second-feet.
December 21, gage height, 3.00 feet; discharge, 699 second-feet.

Daily gage height, in feet, of San Joaquin River at Herndon, California, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.17	4.38	4.00	4.13	7.50	8.37	4.92	3.50	2.83	2.33	2.92	3.00
2	3.00	9.33	4.54	4.38	7.46	7.42	5.21	3.50	2.83	2.50	2.92	3.17
3	3.00	5.17	4.00	4.13	7.67	7.12	5.21	3.42	2.83	2.50	2.92	3.20
4	2.92	4.54	4.00	4.17	8.79	7.29	5.25	3.42	2.83	2.50	2.92	3.20
5	2.96	4.13	4.00	4.21	9.13	7.12	5.00	3.42	2.83	2.50	2.75	3.17
6	3.00	6.46	3.75	4.17	9.25	7.25	5.00	3.29	2.83	2.50	2.75	3.08
7	2.92	5.00	5.29	4.38	9.21	7.12	4.79	3.25	2.75	2.50	2.75	3.00
8	2.92	4.58	4.79	4.46	8.38	7.29	4.50	3.25	2.67	2.50	2.75	3.00
9	2.92	4.13	4.17	5.29	8.25	7.12	4.25	3.37	2.67	2.42	2.66	5.12
10	2.92	4.00	4.00	5.63	8.25	7.04	4.12	3.33	2.54	2.42	2.66	4.75
11	2.92	3.79	4.00	5.71	8.42	6.42	4.12	3.25	2.50	2.42	2.66	3.87
12	3.00	3.67	3.92	6.50	8.58	6.37	4.29	3.25	2.50	2.42	2.66	3.33
13	3.00	3.54	3.83	6.71	9.08	6.50	4.87	3.12	2.50	2.42	2.79	3.04
14	3.00	3.58	3.83	6.83	9.25	6.92	4.79	3.08	2.50	2.50	2.83	3.17
15	3.08	3.50	3.83	7.13	8.96	6.54	4.58	3.00	2.42	2.50	2.75	3.08
16	3.00	3.50	3.75	7.75	8.67	6.21	4.50	3.08	2.33	2.75	2.66	3.12
17	3.00	3.42	3.92	7.79	8.13	5.46	4.33	3.08	2.33	2.75	2.50	3.17
18	3.00	4.13	3.83	8.17	8.21	5.04	4.25	3.08	2.33	2.50	2.50	3.20
19	2.92	4.00	4.75	7.66	8.13	4.70	4.12	3.00	2.38	2.50	2.50	3.08
20	2.92	4.13	4.08	6.87	7.92	4.70	3.96	3.08	2.42	2.50	2.42	3.08
21	2.92	3.96	4.00	6.42	8.83	4.54	3.92	3.08	2.42	2.50	2.42	3.00
22	2.83	3.79	3.92	6.46	9.50	4.42	3.87	3.00	2.33	2.50	5.25	2.92
23	2.83	3.75	3.83	6.29	9.96	4.29	3.83	3.00	2.33	2.50	4.08	2.11
24	2.83	3.58	4.00	6.17	10.17	4.29	3.66	3.00	2.33	2.54	3.50	2.11
25	2.83	3.50	3.92	6.00	9.70	4.33	3.50	3.08	2.33	2.87	4.33	2.83
26	2.83	3.50	4.00	6.71	9.12	4.46	3.50	3.08	2.33	3.08	3.92	2.83
27	2.83	3.42	4.50	7.46	8.58	4.21	3.50	3.08	2.33	3.08	4.54	2.83
28	2.83	3.96	4.29	7.67	8.79	4.21	3.50	3.00	2.33	3.00	3.48	3.17
29	2.83	.....	5.38	7.67	8.87	4.37	3.50	3.00	2.33	2.92	3.04	3.08
30	3.17	.....	4.29	7.54	8.70	4.54	3.50	3.00	2.33	2.92	3.25	3.08
31	3.38	.....	4.08	.....	8.54	.....	3.50	2.92	.....	2.92	.....	3.17

RED MOUNTAIN STATION ON KINGS RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 390, is located 15 miles east of Sanger, California, southwest of Red Mountain and 3 miles below Jarrett's place, and may be reached by roads on either side of the river from Sanger. The station is on what is called "Lower Section of No. 9" of the lumber flume. The gage is made of two 4 by 8-inch timbers 14 and 20 feet long, respectively, laid on the ground under a rock and bolted to a tree. The bench mark is a cross cut in the top of a granite bowlder 11 feet northwest of a blazed sycamore tree at top of rod and 18.045 above the zero of the rod. The initial point of measurement is on the left bank, the "deadman" being at station 50. The channel above and below the station is quite straight. The right bank is high and rocky, but the left is subject to overflow in extreme high water. The bed of the stream is of large gravel and bowlders. The observer is Mrs. Alice House. The following discharge measurements were made by J. B. Lippincott and A. Q. Campbell in 1897:

February 13, gage height, 5.18 feet; discharge, 1,021 second-feet.
April 5, gage height, 6.82 feet; discharge, 2,071 second-feet.
June 1, gage height, 10.02 feet; discharge, 8,838 second-feet.
July 15, gage height, 7.17 feet; discharge, 3,313 second-feet.
September 9, gage height, 4.10 feet; discharge, 295 second-feet.
November 1, gage height, 4.57 feet; discharge, 552 second-feet.
December 22, gage height, 4.70 feet; discharge, 515 second-feet.

Daily gage height, in feet, of Kings River at Red Mountain, California, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.30	9.10	6.00	6.60	9.90	10.20	7.40	5.50	4.30	4.00	4.60	4.90
2	.....	.....	6.02	6.60	9.10	10.40	7.80	5.30	4.30	4.00	4.60	4.90
3	.....	.....	6.03	6.50	9.90	10.20	8.00	5.30	4.40	4.00	4.60	5.00
4	.....	5.90	6.00	6.60	10.50	10.20	7.70	5.30	4.30	3.90	4.50	4.90
5	.....	5.80	5.90	6.80	10.90	10.30	7.50	5.10	4.30	3.90	4.40	4.90
6	.....	.....	7.70	7.50	11.30	10.40	7.40	5.10	4.20	3.90	4.30	4.70
7	.....	.....	8.20	7.20	11.00	10.30	7.30	5.00	4.10	3.90	4.30	4.70
8	.....	.....	6.80	7.50	10.90	10.00	6.70	5.20	4.10	3.90	4.30	9.80
9	.....	.....	6.40	7.90	11.00	10.20	6.60	5.00	4.10	3.80	4.40	6.30
10	.....	5.60	6.40	8.00	11.00	10.20	6.70	5.00	4.00	3.80	4.40	5.70
11	.....	.....	6.20	8.30	11.30	10.00	6.50	4.90	4.10	3.80	4.30	5.30
12	4.30	.....	6.20	8.80	11.40	9.80	7.00	4.90	4.00	3.90	4.30	5.00
13	.....	.....	6.00	9.00	11.40	9.70	7.00	4.80	4.00	4.00	4.30	5.00
14	.....	.....	5.90	9.30	11.60	9.60	7.20	4.80	4.00	4.00	4.40	5.20
15	4.30	.....	5.80	9.60	11.30	9.00	7.20	4.70	4.00	4.60	4.30	5.10
16	.....	.....	5.90	9.70	10.60	8.40	7.20	4.70	4.00	4.00	4.20	4.70
17	.....	.....	6.00	9.90	10.50	7.60	6.80	4.70	3.80	4.30	4.20	4.80
18	.....	.....	5.80	10.10	10.60	7.40	6.50	4.70	3.90	4.30	4.10	4.80
19	4.10	6.30	6.30	9.50	10.90	7.30	6.30	4.80	3.70	4.30	4.10	4.70
20	.....	6.00	6.10	8.80	11.00	7.00	6.20	4.80	3.70	4.30	4.10	4.70
21	.....	5.90	5.90	8.40	11.10	7.00	6.10	4.90	3.80	4.20	6.50	4.70
22	.....	5.70	5.90	8.80	11.60	7.30	6.10	5.10	3.80	4.10	5.10	4.70
23	.....	5.50	5.70	8.30	12.30	7.30	5.90	5.00	3.80	4.10	5.40	4.80
24	4.30	5.50	6.00	8.20	12.40	7.40	6.00	5.00	3.90	4.30	7.00	4.80
25	.....	5.50	6.20	8.40	12.00	7.30	6.00	4.90	3.90	4.50	5.90	4.80
26	.....	5.80	6.80	9.20	11.50	7.30	5.90	4.80	3.80	4.50	5.40	4.60
27	.....	6.00	6.70	9.50	11.40	7.30	5.90	4.70	3.90	4.50	5.00	4.70
28	4.30	6.00	7.80	9.70	11.50	7.20	5.50	4.70	3.90	4.60	5.00	4.60
29	.....	.....	7.20	9.60	11.50	7.10	5.50	4.60	3.90	4.60	4.90	4.60
30	.....	.....	6.90	9.70	11.10	7.20	5.40	4.50	3.90	4.60	4.70	4.60
31	4.70	.....	6.50	.....	11.10	.....	5.40	4.30	.....	4.60	.....	4.60

KINGSBURG STATION ON KINGS RIVER.

This station, as described in the Eighteenth Annual Report, Part IV, page 393, is located at the Southern Pacific Railway bridge, approximately 1 mile south of Kingsburg, California. The vertical gage, the property of the railway company, is nailed to the south central railroad pier, with the zero 31.66 feet below the top of the rail of the bridge. The channel of the stream at the wagon bridge, 200 feet below the railroad bridge, where discharge measurements were first made, is badly broken by the piers of both bridges. The direction of the flow is oblique to both, and the channel contains shifting sand bars. The right bank is not subject to overflow except in very high water, but the left bank is low. Discharge measurements subsequent to April 7, 1897, were made 2 miles above the railroad bridge at Clark's bridge which crosses the river in one span. The section here is uniform and does not change. The water is very deep and slow. The observer is Alf. Thompson. The following discharge measurements were made in 1897 by J. B. Lippincott and A. Q. Campbell:

February 11, gage height, 5.58 feet; discharge, 905 second-feet.
April 6, gage height, 5.20 feet, discharge, 825 second-feet.
June 3, gage height, 8.60 feet, discharge, 5,959 second-feet.
July 17, gage height, 5.02 feet; discharge, 503 second-feet.
September 10, gage height, 3.20 feet; discharge, 221 second-feet.
November 3, gage height, 4.84 feet; discharge, 465 second-feet.
December 23, gage height, 4.80 feet; discharge, 522 second-feet.

Daily gage height, in feet, of Kings River at Kingsburg, California, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.08	5.54	5.63	5.33	8.04	8.83	5.21	4.00	3.17	3.29	5.00	5.04
2	4.00	8.58	6.21	5.79	7.50	8.25	5.37	3.88	3.29	3.33	4.96	5.12
3	3.79	6.63	5.79	5.21	8.08	8.08	5.58	3.75	3.25	3.33	4.83	4.96
4	3.67	6.21	5.92	4.92	8.83	8.12	5.62	3.75	3.25	3.13	4.83	4.92
5	4.08	6.08	5.54	5.08	9.42	8.12	5.50	3.75	3.25	3.08	4.75	4.87
6	4.00	7.13	5.58	5.21	9.58	8.33	5.46	3.66	3.25	3.21	4.70	4.83
7	4.00	6.42	7.58	5.50	9.54	8.37	5.33	3.50	3.25	3.33	4.66	4.75
8	3.67	6.04	6.67	5.75	9.33	8.21	5.12	3.46	3.25	3.50	4.66	4.83
9	3.25	5.88	6.00	5.83	9.17	7.96	4.66	3.50	3.25	3.54	4.37	7.08
10	3.25	5.83	5.92	6.13	9.38	8.00	4.33	3.42	3.17	3.67	4.17	6.08
11	3.17	5.54	5.58	6.54	9.75	7.62	4.54	3.46	3.17	3.67	4.17	5.62
12	3.25	5.33	5.54	6.58	9.71	7.37	4.42	3.50	3.17	3.71	4.17	5.50
13	3.38	5.21	5.46	6.92	9.88	7.42	4.62	3.42	3.00	3.67	4.17	5.50
14	3.92	5.04	5.29	7.33	10.04	7.29	4.79	3.37	3.04	3.75	4.12	5.46
15	4.50	4.92	5.17	7.67	9.83	7.12	5.25	3.25	3.25	4.08	4.08	5.37
16	4.08	4.83	5.00	7.88	10.04	6.92	5.21	3.25	3.25	4.79	4.00	5.29
17	3.88	4.63	5.00	7.88	9.04	6.17	5.04	3.25	3.25	4.62	3.83	5.17
18	3.58	5.75	5.50	8.13	8.79	5.75	4.62	3.21	3.25	4.50	3.75	5.08
19	3.42	5.96	5.67	8.00	8.92	5.54	4.21	3.00	3.25	4.46	3.75	5.08
20	3.42	6.08	5.71	7.54	9.29	5.46	4.08	3.33	3.25	4.50	3.75	4.92
21	3.46	6.00	5.71	6.92	9.75	5.17	3.70	3.33	3.25	4.33	3.75	4.83
22	3.50	5.92	5.38	6.71	10.04	5.04	3.54	3.58	3.37	4.29	6.54	4.75
23	3.50	5.63	4.83	6.54	10.79	5.29	3.29	3.50	3.33	4.33	5.92	4.75
24	3.50	5.42	4.58	6.29	11.33	5.37	3.54	3.25	3.00	4.50	5.75	4.66
25	3.58	5.42	4.58	6.38	10.37	5.46	3.33	3.25	3.04	5.12	6.58	4.83
26	3.50	5.50	4.96	6.71	9.92	5.54	3.50	3.25	3.25	5.08	5.66	4.79
27	3.33	5.50	5.71	7.04	9.54	5.29	3.50	3.96	3.25	5.25	5.46	4.96
28	3.29	5.50	5.46	7.54	9.66	5.25	3.46	3.08	3.33	5.21	5.33	4.96
29	3.58	.....	7.04	7.75	9.70	5.21	3.42	3.25	3.33	5.08	5.12	4.83
30	3.54	.....	6.08	7.83	9.70	5.17	3.50	3.33	3.25	5.00	5.08	4.83
31	4.79	.....	5.50	.....	9.54	.....	3.92	3.17	.....	5.00	.....	4.83

PALMDALE STATION ON LITTLE ROCK CREEK.

This station, as described in the Eighteenth Annual Report, Part IV, page 402, is located about 8 miles southeast of West Palmdale, California, at the headworks of the South Antelope Valley Canal. The creek is diverted through a tunnel into a flume at the headworks, which at the normal stage of the stream will carry all of the water. A gage has been placed in this flume, in which the discharge measurements are made at low stages. During high water a second gaging will be made from the bridge, where the flume crosses the creek, one-half mile below the headworks, and a gage rod will be placed there for that station. The flume is straight. The channel of the stream is crooked and the bed is full of bowlders. The banks are high, and the creek will not leave its present channel at the bridge. The observer is Burt Cole. The following discharge measurements were made in 1897 by J. B. Lippincott and Burt Cole:

February 9, at long flume, gage height, 0.56 foot; discharge, 20 second-feet.
February 9, at headworks flume, gage height, 0.91 foot; discharge, 21 second-feet.
February 9, at long chute, gage height, 0.34 foot; discharge, 21 second-feet.
February 9, at box flume, gage height, 2.00 feet; discharge, 126 second-feet.
March 7, gage height, 1.17 feet; discharge, 26 second-feet.
March 7, gage height, 2.00 feet; discharge, 69 second-feet.
April 7, gage height, 2.80 feet; discharge, 126 second-feet.
April 16, gage height, 0.70 foot; discharge, 14 second-feet.
May 3, gage height, 1.47 feet; discharge, 47 second-feet.
May 15, gage height, 0.45 foot; discharge, 7 second-feet.

Daily gage height, in feet, of Little Rock Creek at Palmdale, California, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.40	2.10	2.25	2.80	2.05	0.40	0.05	0.00	0.00	0.00	0.40	0.35
2	.30	2.50	2.10	2.80	1.95	.40	.05	.00	.00	.00	.40	.30
3	.25	2.25	2.15	2.80	1.80	.40	.05	.00	.00	.05	.40	.30
4	.20	1.70	2.10	2.80	2.00	.40	.03	.00	.00	.10	.40	.30
5	.30	1.75	2.10	2.80	2.00	.40	.03	.00	.00	.10	.40	.30
6	.30	2.05	2.00	2.80	1.85	.40	.03	.00	.00	.15	.40	.30
7	.30	1.60	2.00	2.80	1.80	.40	.03	.00	.00	.20	.40	.30
8	.30	1.50	1.75	2.80	1.65	.40	.02	.00	.00	.20	.40	.30
9	.32	1.22	1.40	2.50	1.65	.40	.02	.00	.00	.25	.40	.35
10	.35	1.15	1.40	2.60	1.55	.40	.00	.00	.00	.30	.40	.35
11	.45	1.00	1.45	2.70	1.45	.40	.00	.00	.00	.40	.40	.35
12	.48	.80	1.45	2.70	1.40	.40	.00	.00	.00	.40	.40	.35
13	.52	.90	1.40	2.70	1.35	.40	.00	.00	.00	.40	.40	.35
14	.42	.80	1.40	2.70	1.25	.40	.00	.00	.00	.40	.40	.35
15	.50	.80	1.40	2.70	1.25	.40	.00	.00	.00	.40	.40	.35
16	.60	.70	1.40	2.70	1.10	.40	.00	.00	.00	.40	.40	.35
17	.62	.70	1.40	2.70	1.00	.40	.00	.00	.00	.40	.40	.35
18	.65	1.55	1.60	2.70	.90	.40	.00	.00	.00	.40	.40	.35
19	.60	1.35	1.60	2.70	.80	.40	.00	.00	.00	.40	.40	.35
20	.55	1.00	1.90	2.35	.70	.40	.00	.00	.00	.40	.40	.35
21	.65	1.00	1.60	2.45	.70	.40	.00	.00	.00	.40	.40	.35
22	.82	1.00	1.60	2.25	.70	.40	.00	.00	.00	.40	.40	.35
23	.80	.90	1.35	2.25	.70	.40	.00	.00	.00	.40	.40	.35
24	.80	.90	1.45	2.20	.70	.40	.00	.00	.00	.40	.40	.35
25	.80	1.00	1.90	2.30	.65	.40	.00	.00	.00	.40	.40	.35
26	.75	1.15	2.60	2.00	.60	.40	.00	.00	.00	.40	.40	.35
27	.60	1.80	2.35	2.15	.55	.35	.00	.00	.00	.40	.40	.35
28	.60	1.70	2.40	2.25	.55	.30	.00	.00	.00	.40	.40	.35
29	.70	.....	2.70	2.25	.60	.25	.00	.00	.00	.40	.35	.35
30	1.10	.....	2.80	2.20	.55	.15	.00	.00	.00	.40	.35	.35
31	1.35	.....	2.80	.....	.45	.....	.00	.00	.....	.40	.....	.35

AZUSA STATION ON SAN GABRIEL RIVER.

This station, described in the Eighteenth Annual Report, Part IV, page 405, is located at the mouth of the San Gabriel River canyon, 2 miles northeast of Azusa, California. During the greater portion of the year all the water of the San Gabriel River is diverted into canals and the measurements of discharge are then made at the division box of the Azusa-Duarte canal. The gage rod is vertical and nailed to the inside of the box, with the zero of the rod at the bottom of the flume, or 1.335 feet below the knife edge of the weir. At times, during the winter season, water flows past the diversion points down the river, and in order to measure this amount a gage rod has been placed in the right bank of the river at a point near the division box. A few hundred feet above is a cable, car, and tag-wire for measuring the floods. R. M. Fellows and H. F. Parkinson are the observers. The bench mark to which both rods are referred is a cross in the wooden sill at the head of the lowest Azusa tunnel. It is 7.97 feet above the zero of the river rod. The channel of the river for 200 feet above and below the cable is straight. The banks are not liable to change. The bed of the stream is full of bowlders embedded in sand. June 4 a diversion dam was placed just below the river gage backing the water up above it. Readings on this rod were then discontinued. The rod and cable were moved up the river later in the season.

The following discharge measurements were made in 1897 by J. B. Lippincott and A. Q. Campbell:

On the river:

January 10, gage height, 1.28 feet; discharge, 4.5 second-feet.
January 25, gage height, 2.00 feet; discharge, 58 second-feet.
February 1, gage height, 5.10 feet; discharge, 1,725 second-feet.
February 2, gage height, 3.40 feet; discharge, 422 second-feet.
March 12, gage height, 3.30 feet; discharge, 410 second-feet.
April 29, gage height, 2.60 feet; discharge, 162 second-feet.
May 24, gage height, 2.08 feet; discharge, 76 second-feet.
November 13, discharge, 8 second-feet.
November 27, discharge, 3.5 second-feet.

In the Division Box.

January 10, gage height, 2.10 feet; discharge, 22 second-feet.
April 29, gage height, 2.88 feet; discharge, 71 second-feet.
May 24, gage height, 2.93 feet; discharge, 68 second-feet.
June 30, gage height, 2.76 feet; discharge, 56 second-feet.
July 5, gage height, 2.72 feet; discharge, 54 second-feet.
August 7, gage height, 2.33 feet; discharge, 31 second-feet.
September 1, gage height, 2.20 feet; discharge, 24 second-feet.
September 29, gage height, 2.10 feet; discharge, 19 second-feet.
November 13, gage height, —— feet; discharge, 25 second-feet.
November 27, gage height, —— feet; discharge, 33 second-feet.

Daily gage height, in feet, of San Gabriel River at Azusa, California, for 1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	Day.	Jan.	Feb.	Mar.	Apr.	May.	June.
1	.....	5.01	3.00	3.10	.....	1.80	17	.....	2.10	3.50	3.05	.....	.....
2	.....	4.00	3.00	3.00	.....	.....	18	2.00	5.00	3.00	3.05	2.20	.....
3	.....	3.00	3.10	3.10	2.50	.....	19	.....	3.90	3.20	3.00	2.15	.....
4	.....	2.90	3.05	3.00	.....	1.80	20	.....	3.60	3.15	2.90	.....	.....
5	1.25	2.55	3.05	3.00	2.50	.....	21	.....	3.20	3.10	2.90	.....	.....
6	1.25	2.60	4.60	3.10	.....	.....	22	2.00	3.00	3.00	2.80	2.05	.....
7	.....	2.50	5.15	3.10	.....	.....	23	2.00	2.95	3.00	2.70	.....	.....
8	.....	2.45	4.30	3.10	2.50	.....	24	.....	2.90	3.00	2.65	2.10	.....
9	.....	2.40	3.80	3.10	.....	.....	25	.....	3.00	3.10	.....	.....	.....
10	1.30	2.35	3.50	3.15	.....	.....	26	.....	3.05	3.10	2.57	.....	.....
11	1.90	2.25	3.45	3.10	.....	.....	27	1.98	3.00	3.10	.....	1.90	.....
12	.....	2.20	3.40	3.15	2.38	.....	28	.....	3.00	3.00	.....	.....	.....
13	.....	2.15	3.30	3.20	.....	.....	29	.....	.....	3.10	.....	1.85	.....
14	.....	2.10	3.20	3.20	.....	.....	30	2.10	.....	3.10	.....	1.80	.....
15	.....	2.10	3.20	3.20	2.25	.....	31	2.05	.....	3.10	.....	.....	.....
16	.....	2.00	3.20	3.07	.....	.....							

WARM SPRINGS STATIONS ON SANTA ANA RIVER.

This station, as described in the Eighteenth Annual Report, Part IV, page 411, is located 5 miles northeast of Mentone, California, three-fourths of a mile below the headworks of the Santa Ana Canal and opposite the Warm Springs in the canyon. The gage is an inclined timber, the lower end of which has been set under the projecting edge of a large bowlder and fastened to upright posts at its upper end. August 31, 1897, a second gage was placed 1 mile above this location and above the headworks of the Santa Ana Canal. The record as published in this report is for the lower gage. The observer is A. Laird, ditch watchman and water divider on the Bear Valley system. The following discharge measurements were made in 1897 by J. B. Lippincott and A. Q. Campbell:

January 27, gage height, —— feet; discharge, 44 second-feet.
March 4, gage height, 1.45 feet; discharge, 101 second-feet.
May 3, gage height, 1.50 feet; discharge, 96 second-feet.
May 4, gage height, 1.50 feet; discharge, 98 second-feet.
June 15, gage height, 1.15 feet; discharge, 64 second-feet.
July 5, gage height, 1.20 feet; discharge, 72 second-feet.
July 6, gage height, 1.11 feet; discharge, 60 second-feet.
August 8, gage height, 1.32 feet; discharge, 56 second-feet.
August 31, gage height, 1.35 feet; discharge, 60 second-feet.
September 30, gage height, 1.13 feet; discharge, 43 second-feet.
November 14, gage height, 1.25 feet; discharge, 40 second-feet.

At new station, 1 mile above old one:

August 31, gage height, 1.00 foot; discharge, 78 second-feet.
September 30, gage height, 0.83 foot; discharge, 65 second-feet.
November 14, gage height, 0.35 foot; discharge, 47 second-feet.

Daily gage height, in feet, of Santa Ana River at Warm Springs, California, for 1897.[1]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Oct.	Nov.	Dec.
1	1.25	2.70	1.60	1.60	1.50	1.10	1.15	1.30	1.30	1.15	1.10
2	1.23	2.10	1.60	1.60	1.50	1.05	1.05	1.35	1.17	1.15	1.05
3	1.00	1.85	1.55	1.55	1.50	1.10	1.10	1.35	1.15	1.15	1.05
4	1.00	1.85	1.50	1.60	1.50	1.15	1.15	1.35	1.15	1.15	1.05
5	1.00	1.65	1.45	1.60	1.50	1.10	1.10	1.35	1.20	1.15	1.05
6	.96	1.65	1.60	1.65	1.50	1.05	1.10	1.30	1.25	1.15	1.05
7	.92	1.65	2.50	1.70	1.50	1.05	1.10	1.30	1.23	1.15	1.05
8	.92	1.80	1.65	1.70	1.45	1.05	1.15	1.35	1.30	1.15	1.05
9	.92	1.85	1.65	1.65	1.40	1.05	1.20	1.35	1.23	1.20	1.05
10	.92	1.65	1.60	1.65	1.30	1.10	1.15	1.35	1.12	1.20	1.05
11	1.12	1.50	1.50	1.75	1.30	1.10	1.20	1.35	1.20	1.30	1.05
12	1.10	1.50	1.50	1.75	1.30	1.10	1.20	1.40	1.20	1.30	1.05
13	1.16	1.50	1.50	1.80	1.30	1.15	1.15	1.40	1.23	1.30	1.05
14	1.21	1.40	1.40	1.80	1.30	1.15	1.25	1.40	2.00	1.27	1.05
15	1.37	1.40	1.50	1.75	1.25	1.20	1.15	1.40	1.25	1.25	1.15
16	1.21	1.35	1.60	1.75	1.25	1.20	1.30	1.30	1.15	1.25	1.05
17	1.40	1.40	1.50	1.75	1.20	1.20	1.20	1.30	1.10	1.20	.95
18	1.40	2.90	1.45	1.80	1.15	1.20	1.20	1.30	.90	1.20	1.00
19	1.35	2.10	1.40	1.80	1.10	1.20	1.20	1.30	.90	1.20	1.00
20	1.35	2.05	1.60	1.80	1.10	1.20	1.15	1.35	.90	1.20	.90
21	1.40	1.70	1.45	1.70	1.10	1.20	1.10	1.45	.90	1.17	.80
22	1.40	1.70	1.40	1.65	1.10	1.20	1.15	1.25	.90	1.15	.80
23	1.45	1.65	1.40	1.60	1.10	1.15	1.15	1.15	.90	1.15	.80
24	1.45	1.60	1.30	1.60	1.15	1.15	1.20	1.25	.95	1.15	.80
25	1.45	1.60	1.35	1.60	1.10	1.15	1.20	1.35	.95	1.25	1.00
26	1.45	1.65	1.35	1.60	1.05	1.20	1.25	1.35	1.05	1.15	1.00
27	1.45	1.55	1.40	1.55	1.00	1.20	1.35	1.30	1.05	1.15	1.00
28	1.45	1.55	1.75	1.60	1.00	1.20	1.30	1.30	1.10	1.15	1.00
29	1.45	.....	1.60	1.55	1.00	1.10	1.30	1.35	1.25	1.15	1.00
30	1.50	.....	1.55	1.50	.95	1.15	1.30	1.35	1.25	1.15	1.00
31	1.45	.....	1.60	.....	.95	.....	1.30	1.35	1.25	.....	1.00

[1] No record for September on lower rod.

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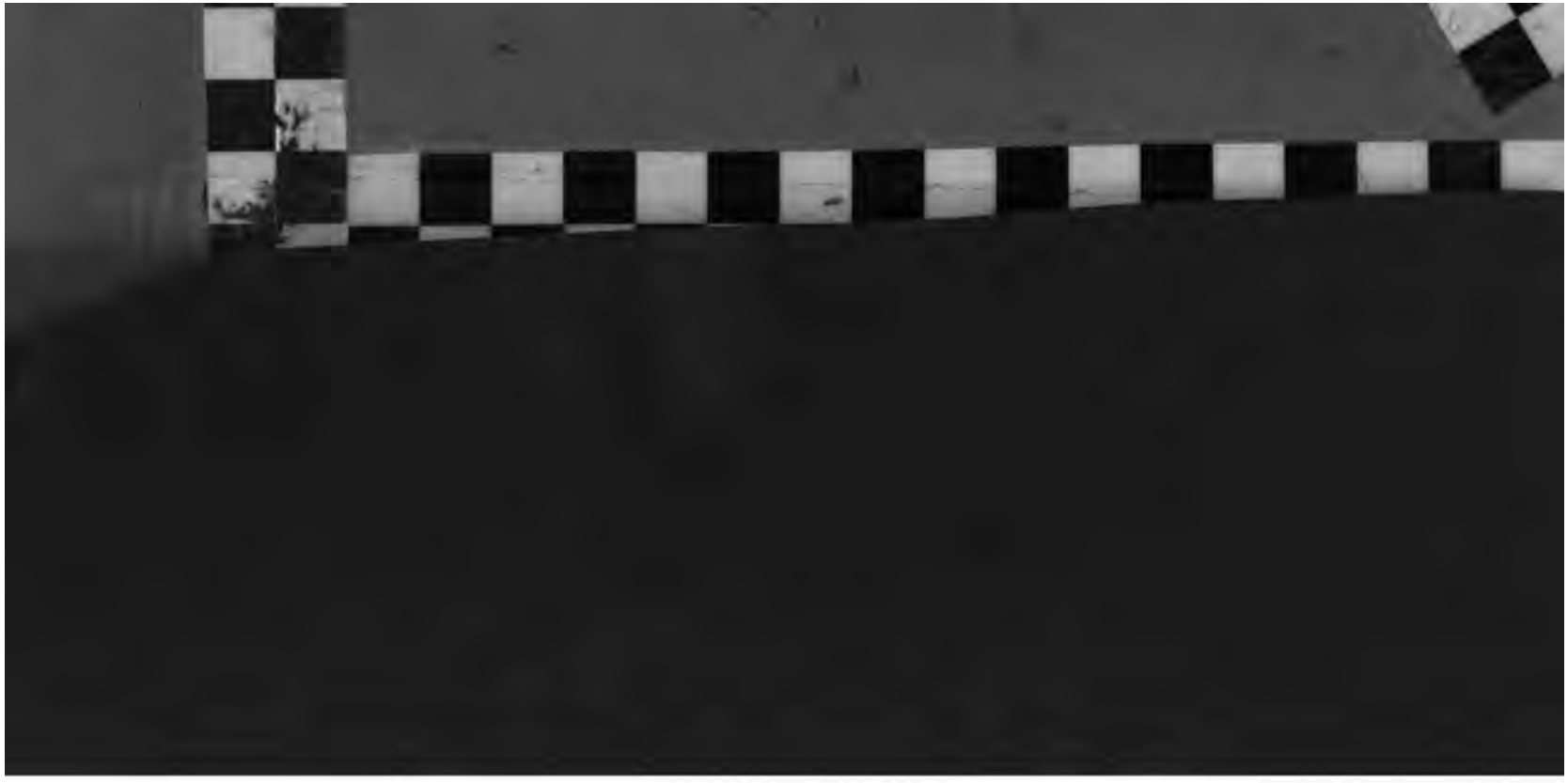

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